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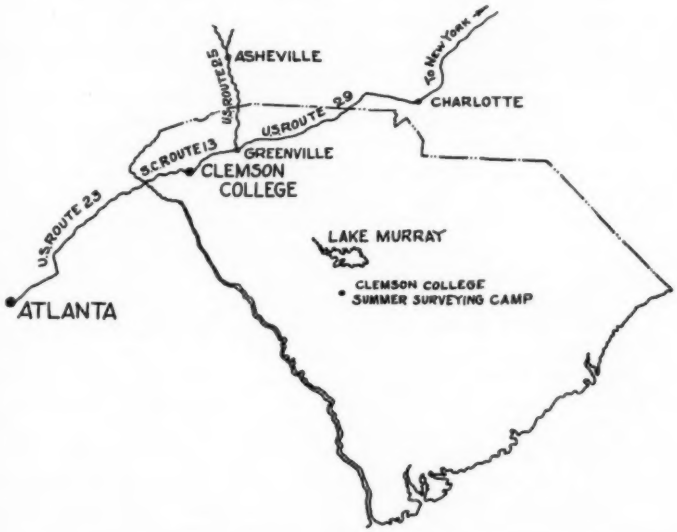
THE CLEMSON LATCH STRING IS HANGING OUT

The S. P. E. E. Convention in Atlanta in June will no doubt attract a number from various sections of the country, many of whom will come by automobile. The members of the S. P. E. E. at Clemson are anxious that as many as can stop here on their way. Arrangements will be made for lunch on Sunday, June 23, at 1:00 P.M., eastern standard time.



The distance from here to Atlanta is approximately 140 miles. The accompanying map shows the route to take for those from the north and northwest coming by Charlotte or Asheville. The road by Clemson from Greenville to Atlanta is as short and as good or better than the other route and far more scenic, as it follows the foothills of the Blue Ridge mountains.

On the Clemson Campus is located the John C. Calhoun mansion which will be open for inspection, and also his office where many of his speeches were prepared.

At Pendleton, four miles from the College, in the cemetery of the old Episcopal Church, is the grave of Barnard E. Bee who

gave Stonewall Jackson his name when he said "There stands Jackson like a stone wall." In Pendleton is also located the Old Farmers Hall which houses the Pendleton Farmers Society. This is supposed to be the oldest farmers' hall occupied by Farmers' Society in the United States and the founding of the Pendleton society ranks fourth in the United States. On the road to Pendleton, about 1½ miles from the College, is located the Old Stone Church which is considerably over 100 years old. The cemetery there contains the graves of Gen. Andrew Pickens and of Gov. Pickens, and many other notables. There is also the grave of Bynum who was killed in the last duel fought in South Carolina by Mr. Perry, who was later Governor of the State.

We would like to hear from those who will be here for lunch by Friday, June 21, so that proper preparations can be made. All those who find they can stop by will please park in front of the Engineering Building, which is centrally located.

THE SPIRIT OF S. P. E. E.

C. C. WILLIAMS, *President of the Society*

The unique character of this Society has had a determining influence on engineering education in America. In the years prior to S. P. E. E., the curriculum had taken structural form, but owing to expansive social and economic conditions, that form had not been subjected to severe testing, the real substance of courses was sometimes uncertain, and the general underlying principles of technical education were variously conceived. The Society overtook engineering education, therefore, at the fork of the road. To the right, the way led to a scientific curriculum and an educational point of view; to the left, to a practical curriculum and an apprenticeship point of view. The founding of this Society, dominated by university men, gave a strong dextral pull, with the result that the *science in engineering* became the essence of the course. This trend is witnessed by the wide adoption at that time of the form of degree, "bachelor of *science in* civil engineering," as descriptive of the character of the course.

Had S. P. E. E. not come into existence, and had engineering education been left to be fashioned by designated divisions of the professional engineering societies, the results would have been different, as is evidenced by events in legal and medical education and in technical education in certain foreign countries where the latter conditions prevail. The fact that for a score of years after the birth of S. P. E. E., two-thirds of the members of the professional engineering societies who were in positions of influence had not been prepared in technical colleges would have had a marked effect under such circumstances. The curriculum probably would have continued along lines in evidence before the close of the last century, more or less static in outlook and bestowing major emphasis on details of design, techniques of field and shop practice, and descriptive information concerning engineering works.

Previous to S. P. E. E., engineering education was essentially a follower; engineering practice, the leader. A casual review of titles in the transactions of engineering societies indicates that a professor of that period rarely had the courage to present a paper, not more than about a half dozen such appearing before 1893. The relatively few engineering text books that emerged from the classroom usually adhered closely to quoted opinions from the practical field rather than venturing to speak on their own authority.

With the advent of S. P. E. E., a group consciousness and a new dignity came to engineering educators, and a self-confidence began to pervade their proceedings. Without dimming their loyalty to their respective professional societies, they found a sphere of service which united them even though their technical affiliations might be divided. The unusual esprit des corps and devotion that immediately characterized the new society resulted in part from a harmony of interests in education and in part from a uniformity in conditions of employment, all members being on salary rather than in competition for retainers. Perhaps, if all engineering had been combined in one comprehensive society, as in some foreign countries, engineering education might have been organized as an educational division of that society. In fact, S. P. E. E. occupies essentially such a position, being functionally the educational division of one universal engineering society, with the universal society removed.

Fortunately, most of the members of S. P. E. E. are not strangers to the ways of practice and many have attained eminence as consulting engineers, so that through their influence, engineering education has been prevented from going to seed on academic stalks. Members have always taken pride in maintaining their status as engineers. While S. P. E. E. is an engineering *education* society, with emphasis on the second qualifying word, it might, with almost equal propriety, be called an educational *engineering* society, for its operations consist largely in applying engineering methodology to education. Its objectives have caused engineering education to find its cue in the aptitudes and interests of young men rather than in license examinations of state boards or in the apprentice specifications of practice. Procedures sponsored by the Society have brought to engineering education recognition as engineering practice, acceptable as fulfilling experience requirements in the professional societies, because the designing of modern courses and laboratory facilities and the efficient administration of classwork and research correspond in essential respects to practical engineering design and execution.

Much of the progress in method, refinement and precision in theory, research, graduate study, experiment stations, and coordination have resulted from the circumstance that engineering education has had its own unified society devoted to the consideration of its particular affairs. The advances in engineering education are quite comparable to those in the technical division of the profession, a fact that sometimes surprises those who have been out of touch for a few years. The development of techniques and methods of handling research and graduate study within the past two decades, requiring very different procedures from undergrad-

uate instruction, illustrates the point. S. P. E. E. has responded to this need with appropriate instrumentalities, such as summer schools and departmental conferences, held in connection with the programs of the national conventions and of the local sections in order to provide opportunities for specialized discussions.

Various movements are stirring which may contest with S. P. E. E. for the council seats of engineering education. Any agency that may seek to wrest leadership in this field from the Society would do well to ponder the record. There appears to be no reason to expect any magic virtue to flow from some other form of organization, since ideas originate with individuals; nor is there any reasonable justification for going back to explore the left fork of the road which engineering education abandoned over forty years ago. Specifically, the spirit of S. P. E. E. is embodied in a faith in fundamental science as a basis of education, a wish to be allied with practical engineering, an amenability to changing conditions, a purpose to discover and to cultivate the native capabilities of a normal portion of educable youth, a readiness to cooperate where feasible, and a willingness to accept responsibility for solving the problems arising within its own domain.

THE CENTER OF POPULATION OF ENGINEERING EDUCATION, 1900–1930

WALTER CROSBY EELLS

Professor of Education, Stanford University

The *center of population* is defined by the United States Census Bureau as "the point upon which the United States would balance, if it were a rigid plane without weight and the population distributed thereon, each individual being assumed to have equal weight and to exert an influence on the central point proportional to his distance from the point." In other words it is the center of gravity or centroid of the plane under the conditions stated.

The determination of this point at the regular decennial census intervals is the best method which has been devised by the United States Census Bureau to trace the rate and direction of general movements of population. The first official computation of this point was made under the direction of Francis A. Walker, superintendent of the ninth census, for publication in the first statistical atlas of the United States, published in 1874.* At that time the position of the center of population was computed for each census year since 1790.

So convinced has the census bureau become of the value of this mode of summarizing population trends that in later years it has made much more extensive use of the same method. In 1910 the positions of the centers of population since 1880 for each state were computed. In 1920 the method was further extended to include centers of foreign-born population, of Negro population, of urban and rural population, and even to determine centers of agriculture, of manufacturing, of number of farms, of farm area, of improved acreage, of value of farm property and of the production of corn, wheat, oats, and cotton.†

* Walker, Francis A. (Compiler), "Statistical Atlas of the United States, Based on the Results of the Ninth Census." Washington, 1874. P. 5. For an earlier unofficial computation by J. E. Hilgard, Superintendent of the U. S. Coast Survey, and other information regarding the history of the concept of center of population, see Walter Crosby Eells, "The Center of Population—a Prophecy and its Fulfilment," *The Scientific Monthly*, XX, 78–84; January 1925.

† Sloane, Charles S. (Compiler), "Center of Population and Median Lines and Center of Area, Agriculture, Manufactures, and Cotton." (Fourteenth Census of the United States, 1920.) Washington, 1923, pp. 12–41.

Why not then educational centers of population as well? A method which has proved so valuable in summarizing movements of general population should be equally valuable for summarizing the similar movements of the higher educational population—the student enrollment in the colleges and universities of the United States.* The object of this paper is to report and discuss the results of computations which have been made by the author to determine the *center of population of engineering education* for each census year from 1900 to 1930, both for engineering education as a whole and for its six principal branches.

Method of Computation

The data upon which the computations are based were taken from the official reports of the United States Office (formerly Bureau) of Education.† These statistics are not perfect, but they are probably as accurate and reliable as are available. The method used was the same as that of the census bureau, with the substitution of "states" (with their centers of population as computed by the census bureau) for "square degrees" as the unit of computation.‡

Location of Centers in 1930

The latitude and longitude and approximate location of seven centers of engineering education in 1930 and of certain related points are shown in Table I and on the map of Fig. 1. The abbreviation "C. S." in Table I indicates that the town named is the county seat of the county in which the given center is located.

* For such a study see Walter Crosby Eells, "The Center of Population of Higher Education," *School and Society* (September 11, 1926), XXIV, 339–44.

† Report of the Commissioner of Education for the year 1899–1900, Vol. 2, pp. 1885, 1899; Report of the Commissioner of Education for the Year Ended June 30, 1910, Vol. II, pp. 857, 859; Biennial Survey of Education 1918–20 (*Bulletin*, 1923, No. 29, Statistics), p. 295; Biennial Survey of Education, 1928–1930 (*Bulletin*, 1931, No. 20), Vol. II, pp. 351–52.

‡ "In making the computations for the location of the center of population it is necessary to assume that the center is at a certain point. Through this point a parallel and a meridian are drawn, crossing the entire country. . . . The product of the population of a given area by its distance from the assumed parallel is called a north or south moment, and the product of the population of the area by its distance from the assumed meridian is called an east or west moment. In calculating north and south moments the distances are measured in minutes of arc; in calculating east and west moments it is necessary to use miles on account of the unequal length of the degrees and minutes in different latitudes. The population of the country is grouped by square degrees—that is, by areas included between consecutive parallels and meridians—as they are convenient units with which to work."—Sloane, Charles S., *loc. cit.*, p. 5.

TABLE I

LOCATION OF CENTER OF POPULATION OF ENGINEERING EDUCATION AND RELATED POINTS, 1930

Point	Latitude North	Longitude West	State	County	Distance from Important Towns
TOTAL ENGINEERING	39° 45′	87° 58′	Illinois	Douglas	27 miles SE. of Urbana 16 miles E. of Tuscola (C.S.)
Civil	39 41	86 58	Indiana	Putnam	27 miles NE. of Terre Haute 7 miles NW. of Greencastle (C.S.)
Electrical	40 50	87 42	Illinois	Iroquois	52 miles NE. of Urbana 4 miles N. of Watseka (C.S.)
Mechanical	40 10	86 18	Indiana	Boone	28 miles NW. of Indianapolis 11 miles NE. of Lebanon (C.S.)
Mining	39 30	96 15	Kansas	Pottawatomie	28 miles NE. of Manhattan 11 miles NE. of Westmoreland (C.S.)
Chemical	39 38	87 18	Indiana	Parke	13 miles NE. of Terre Haute 9 miles SW. of Rockville (C.S.)
Architectural	40 04	89 14	Illinois	Logan	27 miles NE. of Springfield 10 miles SE. of Lincoln (C.S.)
MEN IN HIGHER EDUCATIONAL INSTITUTIONS	39 54	87 03	Indiana	Montgomery	35 miles S. of Lafayette 10 miles SW. of Crawfordsville (C.S.)
CENTER OF GENERAL POPULATION	39 04	87 08	Indiana	Greene	32 miles SE. of Terre Haute 3 miles NE. of Linton
CENTER OF AREA	39 55	98 50	Kansas	Smith	128 miles NW. of Manhattan 10 miles N. of Smith Center (C.S.) 6 miles S. of the Nebraska line

The center of population for engineering education as a whole in 1930, the "population" being the 74,000 students reported as enrolled in all types of engineering courses in the United States that year, was located in Eastern Illinois, about 27 miles southeast of Urbana, 40 miles northwest of Terre Haute, and 75 miles southwest of Lafayette. The University of Illinois, Rose Polytechnic Institute, and Purdue University, therefore, can claim the distinction of being closer to the mathematically computed center of engineering education than any other engineering institutions in the country.

FIG. 1. Location of center of population of engineering education and related points, 1930.

The engineering center is 10 miles south and 49 miles west of the center of population for all men students in the higher educational institutions of the country.* The southern difference probably has slight significance, but the 49 mile difference in longitude reflects a decidedly greater relative westward development of engineering education measured in terms of student enrollments.

The center of engineering education differs still more from the center of general population of the country. It is 47 miles north and 44 miles west of the general center which is located in southern Indiana, or 65 miles from it in a straight line. In comparison with the distribution of population in the country as a whole, there is greater emphasis on engineering education in the north than in

* This point is indicated in Table I, but is not shown in Fig. 1. Its location on the map is almost the same as that indicated for civil engineering, being 15 miles north and 4 miles west of it.

the south; in the west than in the east. This doubtless reflects, in part, the greater need for engineering services in the development of the newer West.

The center of engineering education, however, is still 577 miles east (although only 11 miles south) of that interesting point in Northern Kansas known as the "center of area," the center of gravity of the country if the entire population were distributed over it with uniform density.

If the center of engineering education is broken up into six of its chief component fields, it is found that five of these are located comparatively close to the composite center, while one, mining engineering, is over 400 miles west in Kansas, almost as far west as the center of area. Two are located in Illinois, architectural and electrical engineering, while three are farther east in Indiana—chemical, mechanical, and civil engineering. It may be noted that all of these centers are north of the general center of population, and two, mechanical and civil engineering, are east of it.

Changes in Location of the Centers

Even more interesting and significant than a study of the present situation is an investigation of trends in the centers of engineering education as a whole and of its chief components during the century. It is more important to know where we are going than where we are. Table II reports the location of each center and its movement, in a straight line and north or south and east or west, for the years 1900, 1910, 1920, and 1930.* This information is best visualized with the aid of the larger scale maps of Fig. 2 and Fig. 3. On these two maps the name of the branch of engineering is attached to the earliest point for which data were available, the arrows leading to the locations in the successive decades. With the exception of mining engineering, all of the centers for the past 30 years have been located in Ohio, Indiana, or Illinois. Three were first located in Ohio (architectural, chemical, and civil), but have shifted westward.

The center for all students in engineering moved almost due north from 1900 to 1910, a distance of 23 miles, but since 1910 it has moved steadily southward and westward until in 1930 it was 80 miles west and 25 miles south of its position at the opening of the century. During the same period the general center of population moved west only 71 miles. Westward the course of Empire evidently has taken its way during the twentieth century—but

* Comparable data for earlier years not available. Data not available for chemical engineering for 1900, nor for architectural engineering for 1900 and 1910.

TABLE II

TABLE II

LOCATION AND MOVEMENT OF CENTER OF POPULATION OF ENGINEERING EDUCATION, 1900–1930

Field and Year	Number of Students	Latitude North	Longitude West	Movement in Miles During Preceding Decade				
				From Point to Point in Straight Line	Northward	Southward	Eastward	Westward
TOTAL								
1900	11,415	40° 07′	86° 28′	—	—	—	—	—
1910	30,337	40 27	86 34	23.6	23.1	—	—	5.0
1920	51,908	40 12	87 24	47.2	—	17.3	—	43.9
1930	74,000	39 45	87 58	43.8	—	31.1	—	30.8
CIVIL								
1900	3,140	40 18	83 59	—	—	—	—	—
1910	7,889	40 25	86 47	148.0	8.1	—	—	147.8
1920	8,859	40 09	87 05	24.6	—	18.4	—	16.4
1930	11,563	39 41	86 58	32.9	—	32.3	6.0	—
ELECTRICAL								
1900	2,555	40 21	85 47	—	—	—	—	—
1910	5,450	40 18	88 08	124.7	—	3.5	—	124.6
1920	9,469	40 18	88 17	7.6	0	0	—	7.6
1930	15,647	40 50	87 42	48.3	36.9	—	31.1	—
MECHANICAL								
1900	4,459	39 37	85 13	—	—	—	—	—
1910	6,377	40 14	84 48	47.9	42.7	—	21.8	—
1920	11,789	40 17	87 47	157.7	3.5	—	—	157.7
1930	11,597	40 10	86 18	79.3	—	8.1	78.9	—
MINING								
1900	1,261	40 55	98 22	—	—	—	—	—
1910	2,656	40 57	95 04	175.2	2.3	—	175.2	—
1920	3,219	40 23	95 17	41.0	—	39.2	—	12.1
1930	1,741	39 30	96 15	58.4	—	28.1	—	51.3
CHEMICAL								
1910	869	40 25	84 38	—	—	—	—	—
1920	5,743	40 30	86 14	85.3	5.8	—	—	85.1
1930	6,474	39 38	87 18	82.1	—	60.0	—	56.0
ARCHITECTURAL								
1920	365	41 22	83 55	—	—	—	—	—
1930	1,446	40 04	89 14	308.6	—	89.9	—	295.2

FIG. 2. Location and movement of centers of population of civil, electrical, mechanical, chemical and architectural engineering education, and of the general population, 1900–1930.

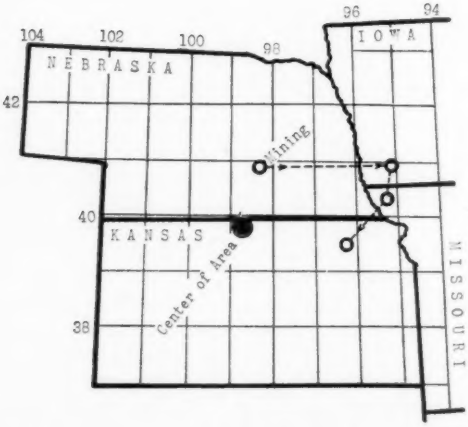


FIG. 3. Location and movement of center of mining education, 1900–1930 and location of center of area of the United States.

more rapidly in the engineering field than on the part of the total population of the coutnry.

Westward movement has not been uniformly characteristic in all fields, eastward movements being registered in one decade each in the fields of civil, electrical, and mining engineering; and in two decades in mechanical engineering. In all fields except mining, however, the 1930 location is west of the earliest one computed. Mechanical engineering, after an exceptionally long westward jump between 1910 and 1920 of 158 miles, reversed itself and returned eastward half that distance during the next decade. The longest jump of all was made by the center for architectural engineering which moved from northwestern Ohio, the farthest east of any of the centers computed, 295 miles westward to a point in central Illinois, farther west than any other center plotted in the three East North Central states of Fig. 2.

The situation with reference to mining engineering, as exhibited in Fig. 3, shows several exceptional features. In the four years under consideration it is found in four different states, Nebraska, Iowa, Missouri, and Kansas. In the period from 1900 to 1910 it travelled 175 miles, the longest shift except for architectural engineering, 20 years later, in any of the fields, and almost twice as great as any other eastward shift. Since 1910 it has moved south and west like the general engineering center, but in 1930 was still 112 miles east of its 1900 location. Its far western location in contrast with other centers, 440 miles west of the general engineering center, is of course due to the development of schools of mines and courses in mining engineering in the western states. Over 38 per cent of the students in mining engineering courses in 1930 were found in the eleven Mountain and Pacific states although these states contained less than 10 per cent of the population of the country.

A study of Fig. 2 indicates that the center of engineering education probably will continue to move southward and westward during the present decade, but a basis for prediction of probable trends in the different component fields is not so clear.

EMPLOYMENT OF YOUNG ENGINEERS

By JAMES C. CLARK

Professor of Electrical Engineering, University of Arizona

The title of this paper suggests numerous important problems. To discuss them adequately would require: (1) a program of research which it has not been possible for me to undertake; (2) a treatment much too long for this occasion. I have chosen to limit my discussion to only those phases of the employment problem which have caused me the most concern during recent months. In a broad way, the body of the paper falls into these three major divisions:

1. The present situation; methods of selection of men.
2. The new competition with engineering education.
3. What the engineering curriculum needs to cope with this competition.

The element which supplies coherence among these three divisions, thus possibly justifying their inclusion in one paper, is that we are concerned not simply with the immediate problem of finding work for present and recent classes of young engineers, but also that we are bound to be interested in what may happen to a long series of future graduates.

As the long-drawn-out depression continues, it becomes increasingly clear that a large proportion of young engineering graduates may not hope to find application soon for their acquired knowledge of the fundamentals of technology, to say nothing of making use of any accumulated information on the existing practice in this or that engineering profession. During the first few months of the depression, while prosperity was still "just around the corner," few, if any, persons thought that well-trained and personable young men would soon find it impossible to enter technical industry in any capacity. A little later, it was particularly difficult for these same young men to accept the fact that industry did not somehow need them. Still more recently, the phenomenon is better understood. The reactions of various young men to this disappointing situation are not merely interesting; they form valuable indexes to the characters of the young men.

A hopeful sign of the times consists in the fact that the registration of students in engineering courses has not fallen off greatly,

or, at least, that it has not decreased so much as to alarm those of us whose jobs depend upon the existence of substantial enrollment of engineering students in the universities. How shall we interpret this? I believe that engineering teachers recognize superior cultural, as well as disciplinary, elements in technical training. But it is far too difficult to believe that the public takes any thought of such elements, even if, by a serious stretch of the imagination, we coax ourselves to think that the mass of the people have any conception of the real nature and purposes of education itself. I like to think that the continued interest in engineering education means that many intelligent persons have faith in the future of engineering, and that not many boys who show promise of achievement in this field are being discouraged by talk of permanently lessened opportunity.

A strangely narrow conception of the engineering field has handicapped engineers and engineering for many years. In particular, it seems as if the whole business of engineering education has been laboring, spell-bound, under ideas expressed by the oft-quoted definition of engineering given by Thomas Tredgold more than 100 years ago, as "the art of directing the great powers of Nature for the service of Man."* In the training of engineers, their minds have been almost entirely occupied with the *physical technique* of one or another of the engineering professions. Professor J. C. L. Fish has clearly demonstrated, in his admirable book "Engineering Economics," that the engineer has no outlet for his activity save through some kind of business unit. Probably many of us feel that an engineering course makes the best preparation for business. If a sufficiently broad definition of engineering is kept in mind, and if the training of young engineers is guided by such a definition, there can be no question about it. This definition is suggested: "Engineering is the direction of the economic use of matter or energy." Examination of the records of successful engineers has shown that a large proportion of them have been drawn into administrative work in business, there to remain. They have laid aside their technical tools, though they retain mastery of

* From the Encyclopedia Brittanica, 14th Ed., 1929: "No better definition of their (the Civil Engineers') aims and functions can be given than that which is contained in the charter, dated 1828, of the Institution of Civil Engineers (London) where civil engineering is described as the 'art of directing the great sources of power in nature for the use and convenience of man, as the means and production of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters, and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns.' "

technique. In some instances, it may have been an expensive process for the employer to instill commercial principles into a stubbornly technical mind, but, even so, it was well worth the cost.

I can hear some of you saying, "It is all very well to talk about the virtues of business training for engineers, but what about the pressing problem of doing something *now* for the graduates of the past three years who are still seeking worthwhile employment, and the 1935 graduates who will soon be added to the throng?" To this, there is no satisfactory answer. Apparently, these men will have to take the best work that they can get if, indeed, there is any work at all for them. The good men will emerge, in time, from the mass, and they will emerge all the more rapidly if they know something of business.

The great stress placed today upon the selling of goods is a familiar phenomenon to all of us. What would we not give for a certain kind of filter for radio programs? There is obviously desperate need for sales. He who can sell goods today can surely find a job. This results in a situation where only those young men who seem to possess exceptionally winning personalities stand any chance of finding profitable employment.

The first test facing most young graduates is one demanding that they sell themselves, usually in a personal interview with the employer's representative. Perhaps this works out well in many instances, but we have evidence that sometimes it does not result advantageously for either party to the interview.

Let us all carry ourselves back in memory to the last term of the senior year in college. Let each of us strive to hark back to the mental condition which he entertained at that time, including those confused notions of the machinery and equipment belonging to his chosen profession. Above all, let each of us recall the most personal equipment which he possessed for making his way in the world; namely, his personality. This may be a bit difficult for the older men among us, but I believe that it is worth while in order that we may possibly be somewhat more sympathetic toward the senior students with whom we deal today. Now, if we have all succeeded in transforming ourselves into the raw and callow youths of yesteryear, let us take one more step in imagination. We seniors have all known for some time that a Mr. Brown would, on a certain day in spring, visit the campus to interview seniors, proposing to "take on," for his concern, a large manufacturing company in the east, an uncertain number of those who most favorably impress him. At last, the day has come. It is a warm day, too, and you have been wondering all morning whether to appear before Mr. Brown just as you are, in your corduroys, your loose and comfortable shirt open at the neck, and with your sleeves rolled

up; or whether to dress up for the occasion. You decide upon the latter course, and you appear in your very best, even to an abhorrent vest, and sporting neatly shined shoes. It sounds silly, doesn't it, that it should have given you serious concern? Yet you really worried over the matter then.

Well, after a long wait among a group of buzzing classmates in the hall, your turn has come, and you go through the door to take part in an interview which is to determine, very largely, your whole future career. For the life of you, memory fails to bring back what was said in the interview, except that you talked very haltingly, being unable to give one solitary reason why the big company should employ you rather than some one else. You do recall, however, that you escaped after fifteen minutes, thanking Mr. Brown for taking so much of his time; also that you dreamed that night of the important engineering work you would do for the great company; also that, sometime during the next morning, the professor told you, you young hopeful, that you had not been chosen.

The years have gone by, you found opportunities, you made your way. Sometimes you have wondered what your life might have been like during all these years had you been chosen to go east to that great company. Perhaps you could have done some wonderful work, who knows? But, in the quarter hour you spent with Mr. Brown, you failed to impress him. Your old professor told you confidentially years later, that he had given Mr. Brown a very high rating for you, not only as to scholarship, but also in such respects as industry, reliability, and personality. You have even wondered sometimes whether it might not really have been better for Mr. Brown's company if that gentleman had discarded his own conclusions about you and accepted, in lieu thereof, your old professor's verdict. But you are a modest fellow, and you never resented the result of Mr. Brown's snap judgment; well, anyway, you never resented it much.

If there is anything to be suggested by this story—and it is not altogether fiction—it is this: very little weight should be given judgments of personality which are reached after fifteen-minute acquaintanceships. Let us say that proper relative weights are to be given to the judgments made by: (1) a professor who has known the candidate rather intimately over a period of two, perhaps more, years; and (2) an interviewer who studies the candidate for fifteen minutes. A proper respective weighting is suggested as 1,000: 1. If the interview is stretched out to 30 minutes or an hour, the suggested weighting would not be materially affected.

As to judgments of *character* reached in a fifteen minute interview, they are worth either zero, or some negative quantity. In short interviews, tremendous errors can be made in estimates of personality, but character cannot be evaluated at all. Of course, this is important, because character is the most vital of all qualifications.

What has just been said in regard to personal interviews should not be construed as a wholesale objection to the practice. No doubt most of us would prefer to see a man whom we propose to employ. Some of us would insist upon it. In that way we may at least learn whether Mr. George Washington Jones is excessively brunette by heritage or by neglect of soap and water. Thus, some employers regard the personal interview as an indispensable part of the process of employing a man; others are quite willing to dispense with it in cases where they may repose entire confidence in the sponsors of the applicant. I contend, however, that it is highly objectionable to base opinions of the personalities of young men on the extremely brief acquaintanceship that is usually feasible to a visiting interviewer.

Let us assume as the most probable future practise that employers will continue to interview prospective recruits among students and that, in general, they will be agreeable to a method involving a very heavy weighting of teachers' estimates of students' personalities and a very light weighting of their own such estimates. It will follow that some ideals must be recognized in the relationships among three interested parties, considered two at a time. These seem entitled to brief mention.

Every means should be embraced by every teacher to know his students thoroughly. Let him not be satisfied with only the teaching of his subject and the testing of the student's knowledge of it, but let him strive also to learn as accurately and fully as possible the character of the student. It seems not only feasible, but highly desirable, for the teacher-student relationship to be such that suggestions may be made by the teacher for the improvement of the student's personality.

The respect of employers for the teacher's judgments of his students varies with employers. It ranges all the way from a zero, or even a negative, value, to an indefinitely great positive value. Certain employers entertain a prejudice toward the practical judgment of professors. This may appear in such violent form that, not only is the professor's opinion ignored, but it is not desired. This attitude may, indeed, go so far that it becomes unwise for the professor to say that his student, Mr. Smith, is a good man. On the other hand, certain other employers will not consider a graduate for employment who has not the whole-hearted

endorsement of his professor. With other employers, the degrees of deference toward the opinion of the professor range all the way between the extremes indicated.

If a teacher is asked, as he should be, by a prospective employer about the characters, capabilities, and personalities of his students, there should always be an honest and accurate report rendered. It seems obvious that this is the only way that entire confidence can be established in the mind of the employer as to the teacher's judgment. I suspect that many of us know older teachers who, in speaking of students, habitually overwork such terms as "outstanding" until it requires effort to learn which, if any, students can be singled out as really outstanding among the small army of alleged "outstanding."

If six thousand students earnestly desire to work for Mr. Brown's company, but Mr. Brown is permitted to offer places to only one hundred of them, it is clear that he may easily obtain most excellent men. There are so many more than one hundred applicants that Mr. Brown may tend to be a bit careless in his selection, or somewhat hard-boiled, or a trifle whimsical. However, I submit that Mr. Brown should be every whit as fair to every one of the six thousand as if he were choosing the hundred from only half a thousand.

It seems to me that, as between courses in engineering and business administration, there is a growing tendency for some students who are potentially good engineers to choose business administration. This is rather natural because the words "business administration" seem, to some innocent minds, to promise more immediate opportunity. If we, in engineering, lose many students who are capable of analytical thought and sound judgments to our friends who ostensibly train directly for administrative work, we are not merely losing numbers who ought to swell our classes, but society itself is ultimately a heavy loser. Therefore, we shall be justified in seeking means to attract those boys into engineering whose make-up of mind and character warrant them to pursue the engineering professions. How this is best to be done is not an easy problem, because it apparently involves the enlightening of the entire public as to the nature of engineering training, and particularly as to the scope and aims of engineering. To discuss possible means of educating the public in the matter would unduly prolong this paper. To emphasize its importance, its actual necessity, is all that I may hope to do here.

It is probably wholly unnecessary for me to argue at any length the superiority of engineering as a foundation for success in modern business. If business to-day requires analytical thinking and logical procedure—and I think it does—it is obvious to all

of us that the study of engineering and the solution of engineering problems, including the problems of engineering economics, furnish the best possible preparation for business.

Engineering courses stand in real need of modification if they are to measure up to the expectations of the most intelligent of those who may choose engineering after wise deliberation over a choice between engineering and business administration. There are some elements in business administration courses that are not usually studied, even as electives, by engineering students. The most essential of these are accounting and corporation finance. It is doubtful that the present four-year engineering course offers enough leeway in the matter of electives to enable substantial knowledge of these subjects to be gained. It should go without saying that all engineering students are provided with a good course in engineering economics.

If there is real justification for the lengthening of the ordinary undergraduate course, it must lie in the necessity that engineering students learn the business subjects that I have just mentioned. In my opinion, there is no justification whatever for an increase of technical requirements for the bachelor's degree.

Summary

1. The depression stresses the need for greater sales, and practically the only demand for young engineers is for those who seem destined for commercial success.

2. There is not a great decline in registration of engineering students. While the reasons for this are not clear, it is hoped that it signifies general faith in industry and in engineering.

3. There is great need for a broader conception of the field of engineering than we have had.

4. Pending the general revival of industry, little, if anything can be done to increase the employment of young engineers.

5. While no objection is raised against the emphasis upon personality, it is believed that great care should be taken to secure that which is desired. In particular, snap judgments of personality are condemned. Respect should be shown for the judgments supplied by teachers whose opportunities for observation are extensive, and whose reports are reliable.

6. Business administration is a strong new competitor with engineering and some minds good enough for engineering are going that way.

7. If engineering courses are to compete with business administration, they must be modified to include the few studies constituting the essentials of preparation for business.

8. It is justifiable and imperative to take steps to educate the public to an appreciation of the broad scope of engineering, in order that it may be understood that successful careers may be built upon an engineering education which includes the essentials of training for business.

When I advocate the study of business by engineering students, I hope that I shall not be understood to mean that we should try to make all our students into salesmen. There are but few students who have the superior character and personality necessary for distinguished success in sales. It is fortunate that the functions of business are far broader than that.

REPORT OF THE COMMITTEE ON INDUSTRIAL ENGINEERING*

(For the Year 1933–34)

During the past year the chairman has corresponded with the other members of the committee, officers of the society and a number of other members of the society who are particularly interested in the work of the committee. A meeting of the committee was held in Ithaca on June 20, 1934.

The committee has been active in making arrangements for holding two conferences at the Ithaca meeting on "Laboratory Procedure in Teaching Machine Production" and on "The Teaching of Engineering Economy." In the case of the conference on Engineering Economy the committee has coöperated with the committees on civil, electrical and mechanical engineering.

The conferences mentioned in the preceding paragraph relate to two of the most important phases of engineering education. The committee believes that the work begun in each of these conferences should continue as a permanent part of the activities of the society, preferably by the formation of a new division of the society in each of these two fields.

The committee on industrial engineering is convinced that engineering teachers and engineering graduates are practically unanimous in the belief that more attention should be devoted, in all engineering curricula, to the economic phases of engineering. There is no such unanimity with regard to the best method to use in reaching the desired objective. The committee hopes that the Ithaca conference on engineering economy will mark the beginning of a real attempt to solve this problem.

The Teaching of Engineering Economy

The members of this committee have a special interest in the teaching of engineering economy. The committee believes that all engineering curricula should contain a course in general economics and, in addition, a course in the fundamentals of engineering economy. The course in general economics should be taught by a man with a thorough training in economics, who should approach

* Presented at the Cornell Meeting, S. P. E. E., June 21–23, 1934.

the subject broadly and fundamentally and not from the specialized standpoint of the engineer.

The course in the fundamentals of engineering economy should be taught by a man with an engineering training, who has also had special training in this particular field. As the fundamentals of engineering economy are the same in all branches of engineering, the same course may well be given in all engineering curricula, with problems selected from the various fields of engineering. It is desirable that the economic phases of engineering should be considered in the specialized technical courses of each curriculum, but this cannot take the place of a separate and distinct course in the fundamentals of engineering economy. Few engineering teachers possess the special training in both the technical and economic phases of a subject that would be required if such a combined course were to fully take the place of a separate course in engineering economy. However, much can and should be done in the specialized technical courses to supplement the separate course in engineering economy. It is a matter of common knowledge that engineering students tend to concentrate on the technical parts of the curriculum. A course which is intended to cover both the technical and economic phases of a subject requires careful handling if the economic phases are to receive the attention they deserve. Specialists are regularly employed in teaching our technical subjects and it seems reasonable that the fundamentals of engineering economy should be taught by specialists in that field.

Management and Administration

This committee believes that all engineering curricula should contain something of the fundamentals of management so as to start the student to thinking about the special problems of management. If an interest is once created, young engineers are much more likely to continue their studies in the science of management after graduation, in preparation for the time when most of them will change from strictly technical work to administrative work.

The committee also believes that engineering colleges are justified in offering a separate management curriculum, provided that this curriculum contains all of the engineering fundamentals, the graduates of this curriculum to receive a distinctive degree. Some engineering colleges now offer such a curriculum and the number is increasing. All of the older major engineering curricula have been developed by adding specialized training in a particular field to the engineering fundamentals. They all give distinctive degrees which indicate the specialized training that has been given.

Some opponents of a single management curriculum have proposed that bilateral options be offered in each of the older engineering curricula, one option to emphasize the technical phases and the other to emphasize the management phases. The committee does not feel that separate management options in each of the older engineering curricula is desirable.

In the first place, the students who elect these management options would naturally expect that a considerable amount of time would be devoted to the fundamentals of management. The board of investigation and coördination (volume I, page 152) suggests that in these management options; "perhaps one-sixth to one-quarter of the entire time might properly be given to studies of engineering economy and administration as such." If any such amount of time is added to the other engineering fundamentals, which should be required of all engineering students, it is apparent that very little of the distinctive technical phases of a particular field of engineering could be given in the management option of that curriculum. Unless a student does specialize to a considerable extent in the distinctive applications of some branch of engineering, he is hardly entitled to a degree which would at least infer such a specialization.

In the second place, the management sciences which would be offered in these management options are the same in all fields of engineering. At least the fundamentals are the same, and there is time for the fundamentals only in a four year engineering curriculum.

The committee believes that these management options would necessarily be so nearly the same in all engineering curricula that it would be much better to have a single management curriculum with a distinctive degree. It is true that most of the present management curricula were developed to meet the special conditions of the manufacturing industries. This is due to the fact that most of the men in this field of teaching were trained in the manufacturing industries. There is no reason why this concentration on the problems of the manufacturing industries should continue.

The committee does not suggest that management curricula in the various engineering colleges should be standardized, but it does believe that there should be a greater uniformity in naming these curricula.

The committee believes that the question of how best to teach the fundamentals of management is one of the most important problems now facing the society, and hopes that the board of investigation and coördination will either review the evidence upon which it based its recommendation against a separate management

curriculum or else make an entirely new investigation of the whole matter.

R. M. BARNES,
C. E. BULLINGER,
E. L. GRANT,
E. D. HAY,
E. D. SMITH,
PAUL T. NORTON, JR., *Chairman,*
Committee No. 9, Industrial Engineering.

AN INDUSTRIAL ENGINEERING CURRICULUM *

By PAUL T. NORTON, Jr.

Professor of Industrial Engineering, Virginia Polytechnic Institute

For a number of years prior to 1929 a commercial engineering curriculum was offered by Virginia Polytechnic Institute. Commercial engineering was identical with mechanical engineering for the first two years, was identical with electrical engineering for applied mechanics and thermodynamics, and practically the same as mechanical engineering for courses in electrical engineering theory. Commercial courses occupied that part of the curriculum which is devoted to engineering specialization in the older engineering curricula. These commercial courses were in the third and fourth years and represented about one year's work.

In 1929 the speaker came to Blacksburg as Professor of Industrial Engineering and was placed in charge of this curriculum. Some of the commercial courses were eliminated, being replaced by several additional engineering courses and by a series of courses designed to outline the principles governing the management of modern manufacturing establishments. The name of the curriculum was changed to industrial engineering. This name better expressed the purpose of the curriculum and is more generally used in the engineering colleges which offer such a curriculum. Graduates of this curriculum receive the degree of Bachelor of Science in Industrial Engineering. The engineering shops were transferred to the industrial engineering department during the year 1929–30.

From the beginning our principal objective has been to make the curriculum a real engineering curriculum, with all of the engineering fundamentals. We believe that the curriculum fulfills this requirement. It includes all of the courses listed as engineering fundamentals on page 88, volume I, of the Report of the Board of Investigation and Coördination. What is more, none of these courses are abbreviated courses. They are identically the same courses as are taken by students in mechanical engineering or electrical engineering. Our industrial engineering students take every course that is common to mechanical engineering and electrical engineering and these three curricula are identical for the first two years.

* Presented at the Cornell Meeting, S. P. E. E., June 21–23, 1934.

It is our purpose to furnish a real engineering training and at the same time to permit students to obtain specialized training in the field of industrial management. It is a well known fact that the great majority of engineering graduates eventually become engaged in administrative work. I am glad to be able to state that a large number of our own electrical and mechanical engineering students and some students in other engineering curricula elect some of the management courses given in our industrial engineering department.

The enrollment in our industrial engineering curriculum has shown an increase each year, the enrollment this year being slightly over one hundred. That there is a demand for engineering graduates with this sort of training is indicated by the success our industrial engineering graduates have had in securing employment. Of the 33 men who received degrees in industrial engineering in June, 1933, a larger percentage had secured employment up to the first of November than was the case with graduates of any of our other engineering curricula. I should judge from the figures published in the September, 1931, and September, 1932, issues of the Journal that this comparatively good record holds also for the industrial engineering graduates of the country as a whole.

Virginia Polytechnic Institute is a military college. Military training is required for only two years but nearly all of our students elect to take it during the entire four years. For such students the requirements for graduation total 228 quarter credit hours. (Our year is divided into three quarters, so that three quarter credit hours are equivalent to two semester credit hours.)

An examination of the courses in our industrial engineering curriculum indicates that (including 30 credit hours of military) 153 credit hours, or 67 per cent of the total, are the same as in electrical engineering and mechanical engineering. An additional 29 credit hours, or 13 per cent of the total, are the same as in either electrical engineering or mechanical engineering. Only 46 credit hours, or 20 per cent of the total, are represented by courses not regularly included in one of the older engineering curricula. Of these 46 credit hours, 10 credit hours are devoted to such technical engineering subjects as metallurgy, heat treating, machine elements and tool design and construction. This leaves only 36 credit hours, or 16 per cent of the total, for courses in the field of management and administration. We should like to increase the amount of time that is devoted to these courses, but do not see how it is possible to do so. We are determined that the curriculum shall be a real engineering curriculum and we will not sacrifice any of what we consider the engineering fundamentals.

INDUSTRIAL ENGINEERING CURRICULUM AT VIRGINIA POLYTECHNIC INSTITUTE

Courses Common to Electrical, Mechanical and Industrial Engineering

	Quarter Credit Hours
Military	30
English composition	9
English and American literature	6
English speech	3
Technical English	3
Chemistry, with laboratory	13
Mathematics, through calculus	27
Physics, with laboratory	16
Statics and dynamics	6
Hydraulics	3
Surveying	2
Engineering drawing	8
Descriptive geometry	4
Mechanism	6
Manufacturing methods (including shops laboratory)	8
Principles of economics	6
Introduction to engineering	2
Hygiene	1
Total	153

Courses Common to Mechanical and Industrial Engineering

	Quarter Credit Hours
Elements of electrical engineering (with lab.)	8
Materials of engineering (with laboratory)	3
Engineering economics	3
Advanced shop laboratory	1
Total	15

Courses Common to Electrical and Industrial Engineering

	Quarter Credit Hours
Strength of materials	3
Heat engineering (with laboratory)	8
Business law	3
Total	14

Courses in Industrial Engineering Only (Some of These Courses Are Elected by Many Students in Other Engineering Curricula)

	Quarter Credit Hours
Metallurgy	3
Heat treating	1
Machine elements	3
Tool design and construction	3

Accounting	9
Introduction to industrial management	5
Production planning	3
Labor problems	6
Corporation finance	3
Wage and salary incentives	3
Standardization and simplification	2
Time and motion study	3
Management formulas	2
Total	46
Total of all courses	228

SHOULD INSTRUCTORS DO OUTSIDE WORK? *

By RICHARD G. TYLER

Dean, College of Engineering, University of Washington

The question as to whether engineering and other technical instructors should be permitted or encouraged to be called in consultation on work outside of their regular instructional duties is a perennial source of controversy. During the depression when engineering work has been scarce the problem has become particularly acute in various sections of the country. Those making complaints are usually among the unemployed and frequently include alumni or ex-students of the institution under criticism.

About a year ago a complaint was made to the Board of Regents of the University of Washington which claimed that members of the faculty of the state institutions of higher learning, namely the University of Washington and Washington State College, in their outside activities were taking $236,000.00 in fees per year, which otherwise would be going to private engineers and other technical experts. A discussion of the matter in the light of our experience in meeting this complaint may be of interest to faculty members in other institutions.

There was nothing particularly new in the type of complaint made except perhaps that it was more voluminously documented than is usually the case. It was both general and specific in character and included the following which are the more important matters which were specifically mentioned.

(1) Consulting work done by the faculty was pointed out as being in direct competition with the alumni of our University and College. It was stated that faculty members on occasion had solicited work and instances were quoted to uphold this claim.

(2) It was complained also that as faculty members had no overhead expense it was possible for them to underbid private engineers and that such competition was therefore unfair.

(3) Routine testing in competition with commercial laboratories came in for considerable criticism and the quality of some of this work was called in question.

(4) There was the usual complaint that faculty members were

* Presented before a meeting of the Pacific Northwest Section, S. P. E. E.

paid from taxes and therefore should not compete with private engineers who were tax-payers and thus in reality their employers.

(5) Finally, it was pointed out that members of the faculty had appeared on opposite sides in various cases under litigation and that it was undignified for experts thus to appear publicly against each other as it was assumed that both could not be in the right.

After this complaint, which was signed by men claiming to be alumni and ex-students of the University, had been received by the University Board of Regents, a committee was appointed by the President of the University to investigate the validity of the criticisms made and report back making recommendations as to method of dealing with the problem. The committee formed a fair cross-section of the faculty and consisted of men who were familiar with most of the charges which had been made.

It was found, upon looking up the records of the complainants, that at least one had had no connection with the University other than through the taking of a single night course in which he had received a grade of "incomplete." Several of the signers were alumni and all were having serious difficulties from curtailment of their engineering and technical practice on account of the depression. A few of the criticisms were quite easily disposed of by securing the facts pertaining to them. For example, one of the cases cited as an example of underbidding turned out to be a case where one of the complainants had put in a bid for a piece of work at a very exorbitant figure while the actual cost of the work as done at the University, when charged at a fair rate, was very considerably less.

Another instance of what was considered unfair competition with commercial laboratories had to do with testing of textile materials for a local department store by the Department of Home Economics. Investigation showed that the department store financed a research fellowship in the Home Economics Department with the understanding that research performed by fellows under this grant should deal with textiles and particularly with some of the problems encountered at this store.

As an instance of an engineer advertising or soliciting work, a news item which I had given to the press with reference to the Soils Laboratory which we were installing was quoted as follows: "Prof. R. G. Tyler states publicly that he hopes to make his new Soils Testing Laboratory of value in working out the special foundation problems peculiar to this state—this laboratory, paid for by public funds and manned by tax-supported faculty men being in direct competition with similar laboratories maintained by private citizens."

This is typical of many of the complaints made and the method of handling it was to call attention to the fact that there was no other Soils Laboratory in the state and that leading engineers engaged on problems of this character in this state had encouraged the establishment of the laboratory for soils research and had utilized its facilities after its establishment in connection with various public works projects.

The complaint that faculty members have less overhead was considered a fair complaint.

Members of the committee were inclined to feel also that it was unfortunate for experts from our state educational institutions to appear in opposition on questions under litigation if it could be avoided. However, it was recognized that such experts were entirely within their rights and that their actions could be impugned with less logic than could those of the attorneys representing the opposite parties in the litigation.

The committee agreed that routine testing, in competition with commercial laboratories, had no real justification. It was felt that unless work accepted by an instructor should have a useful influence upon his value as an instructor, such work was not justified. Routine tests do not appreciably affect the teacher's value as an instructor and since this work is frequently in direct competition with commercial laboratories our committee recommended against its being an appropriate activity for members of our faculty.

After examining into the practice of a number of other educational institutions it was decided to adopt a Code based largely upon a Code suggested by the American Society of Civil Engineers as published in Civil Engineering for November, 1933. This was modified to some extent to fit our local conditions and experience, and is the Code under which we are now working.

In considering the part of the complaint dealing with the income derived from outside work, the committee asked the President to send out a questionnaire covering this matter for the year 1932–33, the last year for which complete data would be obtainable. The attached table shows the result of this questionnaire together with data from a similar questionnaire for 1928–29. It will be seen that the total outside income of members of the staff, or professional activities during the school year, was the very negligible figure of approximately $5,300.00 to be distributed among 50 instructors. It was not considered that summer employment was open to criticism because during the vacation period the instructor is not on salary from the state but is one of the great army of unemployed.

EARNINGS FROM OUTSIDE EMPLOYMENT

University of Washington Faculty

	June 15, 1928–June 15, 1929	June 15, 1932–June 15, 1933
Total Faculty Members	310	303
Number employed outside	58	50
Total money received	$36,185.58	$9,337.61
Average per instructor employed	$623.90	$186.75
*Technical instructors employed	49	40
Total received	$28,755.58	$7,372.61
Average per person	$586.84	$184.31
†Non-technical instructors employed	9	10
Total received	$7,431.00	$1,965.00
Average per person	$825.66	$196.50
Total received for Summer Employment	$18,895.83	$3,995.86
Total received for Winter Employment	$17,289.75	$5,341.75

Before enumerating the arguments pro and con which were considered by the committee I will state that the report with the proposed Code was accepted by the Regents. The latter, armed with the data and information included in the report, then conferred with the complainants and the latter agreed to the Code as presented.

There are certain obvious disadvantages to engineering instructors engaging in outside work. Perhaps the most important of these is that if such work requires too much of his time or interest his instructional work may suffer. It is necessary, therefore, that some supervision be provided and possibly if the time expended on such work should extend beyond a certain agreed percentage of the instructor's time, some arrangement should be made by him for help with his teaching during the period of his engagement. The character of the work done by instructors is also of primary importance. If it is not of suitable character or of a high professional standard it will reflect both upon the instructor and the educational institutions with which he is associated and may suggest that he is not the proper person to occupy a responsible position on the faculty.

State institutions have to consider also that in times of business recession work done by staff members may interfere, to some extent at least, with the business of practicing engineers and thus cause ill feeling and unfavorable publicity which may in turn influence disastrously the state's appropriations for higher education.

* The technical instructors are those in the departments of botany, chemistry, engineering, forestry, geology, home economics, mathematics, mining, pharmacy, physics, and zoology.

† The non-technical instructors are those in the departments of business administration, economics, fine arts, journalism, and law.

The advantages of outside work to the instructor, the institution, and to the engineering profession as a whole, far out-weigh the few disadvantages above mentioned. The effect of these contacts on his teaching is of considerable value and, in fact, is essential to practicality besides adding considerably to the interest and confidence on the part of his students. Income derived therefrom, though it may not be of any considerable magnitude, augments the low salaries paid to professors and makes it possible to keep superior instructors who would not otherwise be obtainable. It is also a tradition of long standing that such work be permitted and engineers seeking teaching as a profession have done so with the expectation of carrying on consulting work in their respective fields after having established a satisfactory reputation therein. Such work encourages and vitalizes research and is thus an important aid to industrial progress. Many research problems arise as a result of outside work and educational institutions have had their part in bringing about our present high state of industrial attainment. It should not be forgotten also that this research frequently produces positions for other engineers—in fact we have had a number of instances of that kind in this institution where as a result of research new industries have been established.

In many cases work is brought to the Engineering College because the judgment of the instructor is considered freer from possibilities of prejudice than the judgments of men depending entirely upon such work for their livelihood. Frequently also there is a need for special equipment or laboratories not available elsewhere than at the University. These laboratories should be available for public work but this can be accomplished *only* through the consulting activities of those in charge.

A point that is sometimes overlooked is that the citizens of the state have a right to consult the University's experts and as these are presumably the best that are available, it would be unfortunate if their services as consultants were not available on important non-University work. Also it has been of great advantage to the profession as a whole, as well as to instructors, for instructors and practicing engineers to work coöperatively on engineering projects of major importance. Both have profited from such contacts and the students of our engineering colleges would feel the effects of curtailment of this coöperation.

Finally, it should not be forgotten that the instructor furnishes a tremendous amount of free advice to members of the profession, to governmental agencies, and to the public, all of which contributes to the general welfare and is not in any sense competitive. When instructors are criticized for competing with alumni of their institutions, one should remember the many instances when an instructor

is called upon to help an alumnus who is struggling with some problem too difficult for him to solve. Every instructor knows how frequently alumni and ex-students write in for advice and counsel which helps them to solve special problems and even to retain their positions. This is work which the instructor is glad to perform but he should be subsidized for it to some extent by being permitted to do other work for which he may receive remuneration.

An instructor who has had no practical engineering experience and who has no opportunity for obtaining it has only a limited usefulness in present day engineering colleges. I believe, therefore, that he should not only be permitted to do outside work, so long as it is of a proper character and does not interfere with his instructional duties, but that he should be expected and encouraged to use outside practice as the most effective means of keeping closely in touch with progress in his field and as a source of inspiration in his teaching.

CONFERENCE ON MODELS *

A CONFERENCE ON MODELS; WHY?

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Centuries ago, when man first began to put together stones or sticks or vines or other materials to form our earliest structures, each such structure became a large scale model—to be tested under actual load conditions so that the next might be more effectively proportioned. Thus for many hundreds, perhaps thousands of years all structural and hydraulic analysis and design may be thought of as definitely dependent upon the use of models. There resulted with certain individuals an intimate knowledge of the action of forces in the structures which they designed and built (for almost invariably the designer was also the builder) such as can be secured only by close association with actual structures under load. Most of the basic forms of construction which we now use (beams, slabs, arches, trusses, cables, aqueduct, canals) were originated by some unrecorded engineer trained by the construction of full scale models. Two thousand years ago, Archimedes, Hero of Alexandria, Vitruvius and Frontinus described engineering projects. Gradually those structures which best served their purpose were developed; strengthened when they showed signs of weakness, and lightened when they seemed to be unduly strong. Many structures were developed which we now recognize as highly efficient. Almost all such structures were of the type which we now classify as "statically indeterminate."

In the early sixteenth century, Palladio built excellent trusses in Italy. In 1758 the Grubenmann brothers built a wood bridge of 390 foot span in Germany. In 1779 Darby built the first metal arch bridge in England. Many early stone arch bridges and aqueducts are still standing. James Finley used the modern type of suspension bridge about 1800. The Canal of Briare and the Languedor Canal were completed in France before 1700. These and hundreds of other structures were successfully completed with little or no rational basis of analysis and design. In 1796 Boistard conducted an exceptionally complete and well planned series of model tests having to do with the location of the line of

* Conference held at the 42d annual meeting, S. P. E. E., Cornell University, June 19, 1934.

pressure and the method of failure of voussoir arches. The results of these tests have been used directly or indirectly in the design of most structures of this type constructed since that time. Dr. Engels has said, "Only through experimentation can hydraulics be made a useful and serviceable science in everyday life." Experiments have always been the background of hydraulic theory. Dubuat, the Frenchman, and Weisbach, the German, were active in the early 1800's. Later Darcy, Bazin, Fargue, Reynolds, Vernon-Harcourt carried on this work and in 1898 Dr. Engels began operation of the "River Hydraulics Laboratory" at Dresden.

About 1700 Newton and the Bernoullis developed the principles of statics and hydraulics. In 1775 L'Ecole des Ponts et Chaussees was started under Peronnet. However, in structures, it was not until 1820 that Navier developed the beam theory; 1847 when Squire Whipple presented the first correct method of truss analysis; 1857 when Clapeyron gave a solution for continuous beams; 1860 when Ritter published his "method of sections"; 1864 when Maxwell presented his method of determining stress graphically. Thus beginning about 1850 there developed a new type of engineer who depended largely on rational theory of analysis and design but who was yet closely associated with the actual construction and operation of the structures which he designed. The statically indeterminate forms of structure were largely supplanted by determinate forms.

Later the functions of the designing engineer and the builder became more sharply differentiated and specialized until frequently the designing engineer had little or no contact with the actual structure either during construction or after it had been put into service. This newer type engineer, thoroughly trained by a technical school in the theory of simple structures and with some years of practical experience, frequently lacks a very complete understanding of the relation of stress to strain, of the effects of continuity, of what may be termed the "feel of the structure." He may have a rather blind faith in the computed primary stresses with little appreciation of the assumptions on which such computations are based. His understanding of the full function of connecting elements may be totally inadequate. Thus with the best technical training in the theory of structures which we can give, it may be that our designing engineers of today who can at best have but little contact with actual structures, may not compare any too favorably with such men as Perronet, Darby, Towne, Rennie, Riquet, Brindley, and others who were forced to design with little or no rational basis of analysis.

Within the past 15 or 20 years a number of new factors have begun to influence analysis and design methods. Reinforced con-

crete and now to a slight extent reinforced brickwork have been recognized as important construction materials. Such materials naturally lend themselves most readily to the continuous type of construction which is inherently statically indeterminate. The use of welding makes it necessary that structures be definitely designed for continuity between parts or that the joints be so detailed as to avoid such continuity. The erection of bridges, buildings and dams of unprecedented size; the creation of great flood and erosion control projects; the construction of new facilities for water supply, irrigation and sanitation; have all created problems of such magnitude that many engineers have questioned the adequacy of our theoretical design methods and have demanded some form of independent physical check on such computations. We have come to appreciate more fully the importance of another group of problems having to do with stress distribution and stress concentrations for which the average engineer has no rational solution. Many of us who teach in the structural or hydraulic fields have found that our effectiveness may be very much increased by the use of demonstration models.

Thus, the use of more continuous type structures for which theoretical analysis may be difficult, tedious, sometimes almost impossible; the design of structures of unprecedented size requiring development and checking of theory, and careful research as to comparative designs and changes in secondary parts of each design; recognition of the importance of stress concentrations and of the usefulness of models for demonstration and instructional purposes, have combined to create a tremendous interest in the use of structural models within the past few years.

Only twelve years ago Professor Beggs presented before the American Concrete Institute meeting in Cleveland the first paper describing the Deformeter Gauges. A few years later Dr. Gottschalk presented a description of the "Continostat" to the Franklin Institute. More recent yet have been the reports of the very interesting work of the Aluminum Company and others on models of dams, of the many three dimensional, loaded models, and of several types of dynamic models. The spread of the use of polarized light in the study of stress concentrations has been phenomenal within the last five years. Within the past few weeks a group of rubber models were used to demonstrate to a committee of the A. R. E. A. that certain of their specifications concerning welds were undesirable. Among the many valuable and interesting analogies which have been proposed may be included: the soap film or membrane analogy, useful in connection with problems of torsion; the sand hill analogy used in plastic flow studies; the hydro-dynamical analogy between flow of a frictionless fluid and stress in a twisted

bar; the electrical flow analogy used in studying stress concentrations; the electrical network analogy by which problems involving the solution of simultaneous equations may be solved. The return of the Freeman scholars from Europe together with the establishment of several important hydraulic laboratories in this country has given an impetus to the already active field of hydraulic model research. Some months ago when the organizing of this conference was first considered I wrote several letters to men whom I thought might be interested in such a conference. I was amazed at the widespread use of models in teaching disclosed in the answers to these letters. A friend of mine located in one of our western states with wide contacts throughout the country, told me of his use of plaster models in a course concerning reinforced concrete, and expressed regret that the subject could not be presented at the conference since he could not attend and there was no one else who made such use of plaster models. I know of at least six other institutions where such models are used. Undoubtedly there are others. And yet I believe that this condition is rather typical with us all. We are familiar with the many spectacular model tests which have been reported in the technical publications but few of us are even aware of the varied uses of models in teaching, or of the tremendous volume of unreported research work completed or now under way which involves the use of models. Such a condition must inevitably lead to a very wasteful duplication of effort. Probably half or more of the very considerable amount of time and money expended during the past three years in the development and use of photo-elastic equipment might have been saved if those engaged in the development might more fully have benefited from the experiences (mostly unreported) of those who pioneered in this field.

A preliminary announcement of this conference gave as its aim the bringing together of a group of men doing pioneer work in the use of models for a pooling of experience, for mutual guidance and for stimulation of interest. We are not, in my opinion, interested in detailed results of any specific model study. We are vitally interested in a thorough understanding of the fundamentals of similitude which are essential to an intelligent planning and interpretation of model studies. We are next interested in the basic principles of each of the various methods of model analysis; in learning of the most informative source material; in hearing of pitfalls to be avoided; in knowing which problems have been or are being adequately investigated, what new studies should be inaugurated immediately to insure rapid advancement of the field as a whole, which other problems seem to be most promising of fruitful results.

The conference has been planned primarily for the younger men—to give them an opportunity to tell of their work, to help them answer such questions as:

Which field shall I choose for future study?
What are the best sources of information?
What problems are there which really warrant investigation?
What is the best technique to follow?
What mistakes should I avoid?

The greatest benefit of any conference usually comes to the individual from informal discussions outside the meeting rooms and from the wider acquaintanceship formed during such discussions.

It is our hope that this conference may illustrate one way in which the designing engineer while receiving his theoretical training may at the same time be shown how, through the use of models, he may gain a clearer conception of the function of the various parts of the structures which he designs; that it may provide guidance and inspiration to those who plan to use models in teaching or research; that it may illustrate a type of coöperative project which may, without a large expenditure of funds for equipment, be carried on jointly by technical schools and industry to the marked advantage of each; that it may be the source of a wider and closer acquaintanceship which inevitably must result in a broader and clearer appreciation of the use of models in those fields in which we are jointly interested.

A possible outgrowth of this conference might be the establishment of a coördinating board to collect and distribute information concerning:

(1) Investigations under way which might be classed as pure research.
(2) Investigations under way which might be classed as commercial.
(3) Uses of models in teaching.

ILLUSTRATING STRUCTURAL PROBLEMS WITH THE DEFORMETER METHOD OF MODEL ANALYSIS

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My definition of the deformeter method is: "The deformeter method is one which employs the use of some mechanical device whereby a deformation of a moment, shear, or direct axial character may be applied to any reaction of a model of a given struc-

ture, or to any cross-section of a member of that model, in order to determine influence lines."

When such a deformation is deliberately applied, the whole model distorts and deflects, and if one measures these deflections at points where loads will be applied to the actual structure, multiplies them by the proper calibration factors, and plots them, he will have an influence diagram for the moment, thrust, direct stress, or reaction component represented by the deliberately applied deformation. There are two types of devices in common use at present, that originated by Professor Beggs of Princeton, and that conceived by Dr. Otto Gottschalk of Buenos Aires.

The Beggs device makes use of a model cut from a sheet about one-tenth inch thick of material such as celluloid, bakelite or cardboard. Since structures may be considered as elastic energy reservoirs, the rôle played by any part of a loaded structure is a function, among other things, of the relative moment of inertia of that part. Since the model is cut from a sheet of uniform thickness, the most convenient way to represent relative moments of inertia of the various parts is to make them proportional in width in the model to the cube roots of the moments of inertia of the corresponding actual full size parts. Accordingly, one computes the moments of inertia of all of the members or parts of the structure to be studied, reduces them to proportional widths to some convenient scale, lays them off on a sheet of model material, and cuts the model out.

Figure 1 shows a typical celluloid model of an arch. Suppose it is desired to derive the influence diagram for thrust at M. All

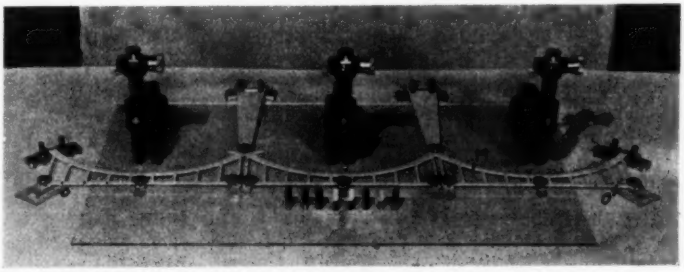

FIG. 1.

one has to do is to cut the model at M at right angles to the axis, move the two sides of the cut apart a small known distance, being careful to keep them parallel, and measure the vertical deflections of the points $O - O'$ on the deck. It has frequently been demon-

strated that the influence diagram ordinate at any point is equal to the vertical deflection at that point divided by the known separation of the sides of the cut at M. In an exactly similar fashion the sheer influence lines may be gotten by moving the two sides of the cut transversely with respect to one another. As for the moment, the two sides of the cut are rotated with respect to one another.

In practice the displacements of the sides of the cut section are brought about by means of a Beggs deformeter gauge and plugs which are inserted therein. The gauge shown at the supports of the arch, Fig. 1, consists of two steel bars drawn toward each other by springs. In the opposing sides of these bars are notches into which the plugs are inserted. The model is first fixed to a drawing board by clamps or by the gauges attached at points of fixity in the actual structure such as the bases of piers, etc. The underside of the model lies in a plane $\frac{5}{8}$-inch from the drawing board and is supported at numerous points upon $\frac{1}{2}$-inch blocks of metal or glass and $\frac{1}{8}$-inch steel ball bearings. The gauge is attached to the model, normal to the axis along which the thrust acts and is supported upon two $\frac{1}{16}$-inch plates between which are three $\frac{1}{8}$-inch steel ball bearings. Two normal plugs, midway in size between the large and small thrust plugs, are inserted before the gauge clamps are tightened. After screwing the clamps down tightly against the model, the normal plugs are removed and the model cut through with a hack-saw blade. Thereafter, whenever the normal plugs are inserted the model resumes exactly the position it was in before the section was cut.

Thrust measurements are made by inserting first the two exactly similar small-size thrust plugs, reading with micrometer microscopes the targets from $O - O'$, and then inserting the large-size thrust plugs and again reading the microscopes. The differences in microscope settings are the deflections.

Shear displacements are produced by inserting the shear plugs, which are also exactly alike, with the flat portion bearing first against one face of the notches and then against the other. This causes one side of the gauge to be displaced laterally with respect to the other, the sides of the cut section remaining parallel and exactly the same distance apart as when the normal plugs are in place. The moment displacements are produced by inserting the two moment plugs, which are of different diameters, and then interchanging them.

I shall merely mention one modification of the Beggs device, namely that originated by Mr. William J. Eney, who studied with me some years ago. Mr. Eney, by making the gauges larger and capable of exerting much greater deformations, has thereby so in-

creased the resulting deflections as to make them readable by an ordinary machinist's micrometer, thus doing away with the microscopes with resulting material decrease in the cost of the apparatus and without serious sacrifice of accuracy.

As to the use of the Beggs type of apparatus in illustrating structural problems, I have found it most useful in connection with advanced students. In the investigation of rigid frames and arches, for example, I always insist that analyses by the elastic theory be checked by a model determination. This accomplishes one very important thing; it instills in the student both confidence and respect for the theory in much the same way that making check measurements of predicted stress conditions in the actual structure would do. Seeing is believing!

In the field of research I have also found the Beggs device most useful. I recall having made the model analysis of the Yadkin River Arch which was also treated by the elastic theory and, in addition, the predicted stresses due to known loads were checked with telemeters in the field. All three determinations checked with surprising accuracy.*

One of my graduate students also investigated the temperature stresses in an open spandrel arch with this device with great success. Time prohibits my going into any detail.†

You have no doubt all heard of the Mt. Vernon Memorial Boulevard which reaches from Washington to Mt. Vernon. On this highway there are eleven bridges, including several arches with abutments resting on pile nests as well as some rigid frame bridges similar to those employed by the Westchester County Park Commission. I was able to check the computations on these bridges successfully with the Beggs device and to point out needed revisions in the designs. Again, time prohibits going into detail.

Of course you all know of the work of the French engineer, Freyssinet, who originated the construction method which employs jacks in the crowns of arches for the purpose of raising them off their centers and subsequently adjusting them so as to obviate most of the parasitical stress. I have demonstrated this method to students with the Beggs gauges with good results. All one has to do is to mount a cardboard model of a simple arch rib with a single gauge at the crown. When larger and larger thrust plugs are inserted, the action of the model rib is exactly comparable to that of an arch being raised by the Freyssinet jacks. The students get the idea immediately.

* J. T. Thompson, Highway Research Specialist, United States Bureau of Public Roads, "Model Analysis of a Reinforced Concrete Arch," *Public Roads*, Volume 9, January, 1929, p. 209.

† Karl E. Erthal, Jun. Am. Soc. C. E., "Study of Bridge Model," *Civil Engineering*, Vol. 3, March, 1933, p. 178.

The second type of device is the so-called Continostat-Gottschalk. This instrument consists essentially of a straight-edge upon which are mounted knife edge supports for steel splines. The knife edge supports are susceptible of movement both along the straight-edge and at right angles thereto. The steel splines are about $\frac{3}{8}$-inch in width and are of variable thickness, so that one may select a spline of proper thickness to represent the proportional stiffness of the member to be stimulated in the model.*

Suppose one wishes to evaluate the reaction R for a continuous beam. All one has to do is to push the corresponding knife edge up a distance unity to some scale. The elastic line of the spline is then the influence diagram for the reaction. An exactly similar argument can be applied in finding the influence diagram for shear at any point. As for moment, a special clamp is provided which draws the ends of two splines together with an internal angle of 126°. It can be demonstrated that for sections near the central portions of all spans the peaks of the moment influence diagrams have an internal angle closely approximating this value. Hence, when such a clamp is applied to a model of a beam, it automatically draws the spline into the influence diagram for moment.

It is an interesting experiment to set a group of students at work deriving analytically the influence diagrams for a continuous beam and, after they have completed it by repeated applications of the three moment equation, to rig this device up and have an influence diagram pop out at them instantly. Again, respect for and confidence in our methods of computation are instilled, although I will not say that they feel as friendly toward the originator of the three moment equation as they do toward Dr. Gottschalk.

In more complicated structures than the one discussed, such, for example, as portals and other rigid frames, the splines are connected together with special clamps, but the principle just described applies equally well to these.

An interesting modification of the Continostat-Gottschalk is that devised by Mr. Anders Bull.†

Lack of time prevents going into any detail, except to say that Bull uses brass drill rods which he solders together to form the necessary model. In this manner he does away entirely with all clamps and other special pieces of apparatus and produces a perfectly workable model at minimum expense.

* Otto Gottschalk, C.E., "Mechanical Calculations of Elastic Systems," *Journal of the Franklin Institute*, July, 1926, p. 61.

† Anders Bull, "Brass Wire Models to Solve Indeterminate Structures," *Engineering News-Record*, Volume 99, December 8, 1927, p. 920.

In contrast to the Beggs instrument, I have found the Gottschalk type more useful in instructing undergraduate students. It is possible for them to set the apparatus up very quickly and to secure the influence lines immediately without the use of microscopes which always require a lot of time.

In the field of research I have found just one use for the Continostat. It was proposed to build a concrete arch deck with a shear-lock type of expansion joint. The problem was highly indeterminate but by gluing on to the ends of the splines little celluloid hinges with a pin driven through them, I was able to secure the necessary influence lines.

To contrast these two applications of the deformeter method, I will sum up in a few words the advantages and disadvantages of each. Beggs' apparatus is much higher in cost, necessitates models produced with greater trouble and requires the use of microscopes, which is tiring, laborious and time-consuming. On the other hand, it lends itself to all sorts of intricate applications. It is hard to conceive of a structure for which a model could not be devised. In my opinion, greater accuracy is obtainable with Professor Beggs' gauges. The Eney modification tends to eliminate some of the disadvantages.

The Gottschalk device does not require the use of microscopes and is therefore considerably cheaper. It is faster and less tiring, but it possesses one very serious defect, namely it does not lend itself well to model fabrication if the structure to be represented is at all complicated. The Bull modification reduces costs and eliminates the serious difficulties met with in model fabrication.

In conclusion I think it well to issue a general note of warning. While in many instances it is true that the elastic theory requires the patience of Job and the longevity of Methuselah, the deformeter method should not be considered a panacea for this evil. I look upon it as a desirable method for securing a check on analytical computations and as a scheme whereby solutions may be obtained in cases which are next door to impossible from the analytical viewpoint. The student should be warned against the conception that these devices are magical little gadgets which produce a solution by the mere turn of a crank. The belief that one can use them without thorough theoretical training and structural experience is as erroneous as the thought that one can learn to be an engineer in four years of college attendance.

THE VARIOUS TYPES OF LOADED * MODELS AND SOME PROBLEMS TO WHICH THEIR USE IS ADAPTED

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Synopsis

A model vs. a specimen.

A structural model is used to show the behavior of the *structure* (the prototype) under load and is used for demonstration or as an aid in analysis.

A specimen represents the *material* of a member or a structure and is used for the determination of its physical constants and as a check on its quality and uniformity.

Classification of models.

I. *Similar models.* (Resemble the structure or prototype. Current authorities are Bridgman and Groat. See references listed in 5, p. 159, and statement by Carlson (5, p. 139).

A. Elastic models (follow Hooke's Law).

1. *Displacement models.*

(*a*) *Stress mono-axial.* Determinations depend upon measurements of deformations, deflections, rotations or other displacements by means of strain gages, dials, extensometers, deformeters (Beggs), clinometers, mirrors, etc. Material must be elastic in direction of stress. Material need not be the same as that of prototype. Method applicable to simple units such as beams, columns, etc., and for many trusses, suspension bridges and parts of arches. Widely used. Beggs is a pioneer in this field. References: 1, p. 241; 5, p. 161; 6, p. 100.

(*b*) *Stresses bi-axial or tri-axial.* Only difference from above is added requirement that Poisson's ratio be same for material of model as for prototype and that the material be isotropic (same stress characteristics in different directions). Examples of structures in this class are dams, arches in the vicinity of abutments, two-way slabs, parts of many trusses, etc. Engineering Foundation (U. S. Bur. of Reclamation) and Aluminum

* Extended to include methods of analogy for some of which the models are not loaded in the same manner as the prototype.

Company of America (Karpov and Templin) have pioneered in this field. References: 5, p. 163; 6, p. 100; 10; 11; 12; 13; 14; 15; 16; 22.

2. *Photo-elastic models.* Determinations depend upon visible optical effects from passing polarized light through loaded models. Material must be elastic, transparent, isotropic and free from initial or residual stresses. Bakelite, celluloid and glass have been used successfully. Usually limited to plane states of stress or strain. Excellent for demonstration purposes as well as for research. Widely used, especially for determination of regions of stress concentrations. Pioneers in the field, Brewster and Coker. Among the many present workers in this country are Frocht, Beyer, Solakian, Hollister, Jensen and Brahtz. References: 1, p. 203; 2; 4; 5, p. 164; 6, p. 100; 17.

3. *Brittle material models.* Material used for models must follow Hooke's Law (have a straight line stress-strain diagram) to failure. A simple specimen for which stresses can be computed is tested to failure. The less simple member (the model) is loaded to failure. The intensity of the maximum stress is assumed to be the same as that of the simple specimen and it is possible to work out the relationship between this stress and the load carried. The distribution may also be computed in many cases. Thus far the method has been used for relatively simple models, and, being new, both its possibilities and its limitations are practically undetermined. A good grade of potter's plaster has been the material used. Seely and James developed the method. Lightburn and others are exploring the field further. References: 1, p. 194; 5, p. 164; 6, p. 98.

B. Non-elastic Models.

1. *Displacement models.* Similar displacement models may be used in the non-elastic ranges of stress. Interpretations of results are hazardous because the behavior of any structure is influenced greatly by the redistribution of stresses which follows the first yielding of the material. If the spot of initial yielding differs for model and prototype, the subsequent behavior of the two may bear little resemblance. Non-elastic models of this type are rarely used intentionally but both models and structures which are re-

quired to sustain their load for a period of time undergo time-yield in the regions of higher stresses. This case will assume increasing importance as model testing advances and refinements are introduced. References: 19; 20.

2. *Slip-line models* (*Lueders Lines*). A large plastic deformation occurs along planes of maximum shearing stress when a material approaches its yield point in tension or compression. These show as slip lines or Lueders Lines on a polished metal surface and may be employed as a means of determination of regions of stress concentration. Paraffin shows slip lines clearly. References: 1, p. 196; 2; 3, p. 115; 6, p. 99–100.
3. *Brittle paint models.* Similar to above except that surface of model is coated with a brittle paint such as a portland cement grout. This scales wherever the yield point of adjacent material is reached. The yield-point scaling of the iron oxide coating from hot-rolled steel is probably the commonest illustration of the action. The oxide scaling has frequently figured as evidence in post-mortem studies of structural failures as well as in the examination of structures whose safety is questioned. References: 1, p. 195; 2; 6, p. 100.

II. *Dissimilar Models.* Models which bear little or no resemblance to the structure being analyzed but from the manipulation of which useful information can be obtained regarding the behavior of the structure.

A. Elastic analogies.

1. *Membrane analogy* (*soap film*). Useful for determination of torsional stresses in members of any cross-section. Intensity of torsional stress proportional to slope of elastic membrane of same shape as cross-section and subjected to uniform pressure. Developed by Taylor and Griffith. Use increasing. References: 1, p. 169, 206; 2; 6, p. 100.
2. *Hydro-dynamical analogy.* Based upon mathematical relationship between the equations of motion of a frictionless fluid and the stress distribution in a twisted bar of circular cross-section and variable diameter. Developed by Kelvin & Tait. References: 1, p. 238; 2; 6, p. 100.
3. *Electrical analogy.* Based upon the mathematical relationship between the distribution of torsional stress

in a shaft of variable diameter and the distribution of electrical current in a plate of variable width and thickness. Developed by L. S. Jacobsen. Reference: 1, p. 205; 2; 6, p. 100.

4. *Slab analogy.* Based on the mathematical relationship between the stress function for a slice of a structure and the shape taken by a distorted elastic slab. First used experimentally by Wieghardt, 1908, and developed further by Westergaard, Jensen and the U. S. Bureau of Reclamation engineers in connection with unpublished studies of Boulder Dam. References: 7; 8.

B. Plastic analogies.

1. *Sand-heap analogy.* Based on the mathematical relationship between the shearing stress distribution in a bar of any cross-section which has been twisted until parts of it are stressed to its yield point and the shape taken by a heap of fine sand placed upon a plate of the same shape as the cross-section of the bar. Reference: 3, p. 132.

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22. U. S. BUREAU RECLAMATION has tests in progress on models of Tennessee Valley and Columbia River Dams at Univ. of Colorado.

SECTIONS AND BRANCHES

The fifth annual meeting of the **Arkansas-Oklahoma Section** was held at the University of Arkansas and was opened with dinner at Hotel Washington. President Stelzner welcomed the 85 visiting members and guests, after which President J. C. Futrall, University of Arkansas, was introduced and spoke briefly of the trend toward a five-year curriculum in the College of Engineering.

At the conclusion of President Futrall's speech, Dean J. H. Felgar, University of Oklahoma, expressed his belief that increased legal status, comparable to that held by the professions of law and medicine, is needed for the profession of engineering if further advancement is to be attained in the future. Dean W. N. Gladson, University of Arkansas, read a paper entitled: "The Work of the Fact Finding Commission of Arkansas, Dealing with Public Utilities."

At the Saturday morning session F. G. Tappan, University of Oklahoma, presented a paper, "The Engineers Council for Professional Development." The second paper, given by J. C. Davis, University of Oklahoma, was concerned with "The General Engineering Course and its Place or Future." This paper was discussed by C. A. Dunn, Oklahoma A. & M. College.

A round table discussion on "The Scholarship Committee and its Problems" was opened by R. C. Wray, University of Arkansas, followed with discussions by C. T. Almquist, University of Oklahoma and L. F. Sheerar, Oklahoma A. & M. College.

The second round table discussion, which followed at the conclusion of the first, was on the subject: "The Junior College Plan and the Engineering College." This discussion was lead by H. L. Kent, Oklahoma A. & M. College, and supported by L. Crabbe, University of Oklahoma, and A. G. Holmes, Jr., University of Arkansas.

Professor C. L. Farrar, chairman of the Committee on Constition and By-Laws reported that "the Committee offered no recommendations for change."

Dean J. H. Felgar, University of Oklahoma, extended an invitation, on behalf of the S. P. E. E. members of the University of Oklahoma, to have the Section meeting at Norman, Oklahoma, in 1936. The invitation was accepted by unanimous vote.

C. R. Nichols of Arkansas Technological College, Russelville, Ark., discussed his experiences in and his viewpoint of the junior

college. H. L. Kent, Oklahoma A. & M. College, replied to Mr. Nichols' discussion.

The following officers were elected for 1935–36:

C. L. Farrar, University of Oklahoma, *President,*
C. R. Wood, Oklahoma A. & M., *1st Vice-President,*
A. S. Brown, University of Arkansas, *2d Vice-President,*
L. A. Comp, University of Oklahoma, *Secretary-Treasurer.*

A. S. Brown,
Secretary.

THE COURSE IN GENERAL ENGINEERING—ITS PLACE OR FUTURE

By JAMES C. DAVIS
University of Oklahoma

General Engineering as it is being worked out at Oklahoma University is still, more or less, in the experimental stage and, though numbers have not entered into the consideration (only such students having been enrolled as signified a desire for the particular advantages of the course), the type desiring the general engineering course and their zeal in pursuance of the work have proved to our satisfaction that we are filling a need which warrants the addition of a General Engineering Course to the Outline of Engineering Courses.

Fortunately, some students who enter our engineering colleges, due to background and experience, come with definite notions concerning the course they wish to pursue and can choose wisely at an early stage of their development. They enter the restricted field of their choice—electrical, civil, mechanical, and so on—and give a good account of themselves or an indifferent account, as the case may be. They come knowing what they want and there is no deviation. There are others, however, a limited number, who come with equally definite ideas concerning what they want but who find the restricted field hardly the introduction they need. I refer to those particularly interested in experimental work—the managerial field, salesmanship, or in general research—as a dream of the far future. To this restricted group an attack of the simpler general problems of the entire engineering field, leading on to more difficult ones and to their own individual problems in the end, has seemed not only theoretically sound but wise in practice.

As time goes on, there is an increasing demand for graduates of engineering schools who are equipped to carry on experimental and research work. They must have a fundamental knowledge of

the various engineering fields, a fair acquaintance with materials, and a sufficient knowledge of mechanics, physics, and chemistry to enable them to attack their problems as they arise. In the experimental field the problem is not always ended with its solution or partial solution, for many times it is necessary for the experimenter to present his solution to others in authority in an understandable and forceful manner. To do this, he must be able not only to think accurately and logically himself, but must have some training in accurate reasoning and in the basic principles of logical presentation. Then, too, he must understand economic problems; he must understand men in the matter of normal or abnormal reactions to what he is trying to present. Unless the experimenter possesses the ability to put the matter in hand clearly before others, he may fail in the end.

The student who enters with the idea of preparing himself for the sales position or the managerial position in the profession must obtain a fundamental knowledge of the different branches of engineering, together with the elements of business and a good general educational training. To meet the requirements of such a course, there must of necessity be some considerable elective work. Knowledge is needed for both technical and non-technical problems. These are often of an economic, psychological, or technical nature. Inability to handle any of these various phases may mark the dividing line between success and failure.

Now, unfortunately, there is the third group, coming to us each year, who though they bring splendid high school scholastic records both in mathematics and in the natural sciences, choose engineering without a doubt yet are not fully determined concerning the course they wish to pursue. In the entire freshman year only a small amount of real engineering is contacted—a little drawing, a little shop, and some simple engineering applications which give some insight into the engineer's problems. At this stage of his development he is usually expected to make the choice of the particular branch of engineering which he intends to follow. His choice is often made because some upperclassman friend tells him that such and such a school has the greatest merits, or because some department head impresses him most favorably when he presents the advantages of a particular school. Thus he becomes a mechanical, civil, or "what not" engineering student. He pursues his course diligently, oftimes doing excellent work, but still finds himself dissatisfied with his choice after reaching the second half of his junior or first half of his senior year. Some few will then change to another course. Most of them go on, however, complete their work, receive their degree, and enter into a branch of engineering for which they are illy suited. They may carry

on through life in a profession for which they have little taste, or else, after a few years, may become completely disgusted and change to some other line of work, oftentimes not related to engineering. A General Engineering course may offer the solution here, and many a good man may be helped to find himself and to enter into a broader understanding of general engineering problems.

The following is a brief outline of the course in General Engineering as offered at Oklahoma University—a course leading to the degree of B.S. in General Engineering.

School of General Engineering

First Year

FIRST SEMESTER		SECOND SEMESTER	
Courses	*Hours*	*Courses*	*Hours*
Chem. 1, or 3, Gen. Chem.	5	Chem. 4, Qual. Anal.	3
Eng. 1, Eng. Comp.	3	Eng. 2, Eng. Comp.	3
Math. 5, Col. Alg.	3	Engr. 1, Engr. Prob.	3
Math. 6, Trig.	3	Math. 14, Anal. Geom.	4
E. Draw. 1, Technical	2	E. Drawing 2, Tech. (con.)	2
Mil. Sc. or Phys. Ed.	1	Shop 1, Wood	1
Freshman Conference		Mil. Sc. or Phys. Ed.	1
		Freshman Conference	
Total	17	Total	17

Second Year

E. Draw. 3, Des. Geom.	2	Math. 18, Calc. (con.)	4
Math. 17, Calc.	4	Physics 52, Gen. (con.)	5
Physics 51, Gen.	5	English 34, Amer. Lit.	3
Gov't 1, Gov't of U. S. or		Econ. 40, Principles	5
Hist. 43, U. S. Hist.	3	Mil. Sc. or Phys. Ed.	1
Pub. Speak. 3, Effective Spk.	2		
Mil. Sc. or Phys. Ed.	1	Total	18
Eng. 119, Avd. Comp.	2		
Total	19		

Third Year

Mechs. 251, App. Mech.	4	Mechs. 253, Str. of Mater.	4
Mechs. 252, Graphics	1	Mechs. 254, Test Mater.	1
E.E. 155, Dir. & Alt. Cur.		*C.E. 140, Masonry	4
Mach	4	Engineering 101, Contracts	3
E.E. 156—Dir. & Alt. Cur.		Acct. 51, Elem. Acct.	3
Lab.	1	Mech. 257, Mat. of Engrg.	3
C.E. 3, Surveying	3		
Chem. 71, Gen. Metallurgy	3	Total	18
Geol. 22, Engr. Geology	3		
Total	19		

* C.E. 205, Architectural Building, C.E. 233, Reinforced Concrete, or C.E. 265, Structural Engineering, may be substituted for C.E. 140.

Fourth Year

M.E. 104, Elem. Thermody ..	3	*M.E. 154, Power Plant	3
Mechs. 255, Hydraulics	3	†Math. 125, Theory of Equations	3
C.E. 272, Engr. Economics ..	2	Mech. 258, Mach. Movements and Forces	3
Elective (Technical)	6	Elective (Technical)	6
Elective (Nonscientific)	4	Elective (Nonscientific)	4
Total	18	Total	19

In this course an attempt has been made to offer and to require such courses as are fundamental to all the engineering schools and at the same time to pursue such other subjects as will give a fairly liberal education. The same mathematics, physics, chemistry, and mechanics subjects have been placed in the curriculum. The General Engineering School has added one additional mathematics course, "Theory of Equations"; one chemistry, "General Metallurgy"; and two mechanics subjects, "Materials of Engineering" and "Machine Movements and Forces." Selective fundamental courses have been chosen from mechanical, electrical, civil, and geological engineering. From mechanical engineering, thermodynamics, and a choice of either steam power plants or internal combustion engines; from electrical engineering, direct and alternating current machinery (both classroom and laboratory instruction); from civil, the elements of surveying, and choice from courses in masonry, architectural building, structural design and reinforced concrete; from geological engineering a course in engineering geology.

Basic courses have been chosen from English, history or government, public speaking, economics, accounting, and engineering contracts. Three courses in English composition and one in American literature, twelve hours of technical elective, and eight hours of non-technical elective are required. Where the subjects are pursued in their logical order, the elective subjects come in the senior year. Most students are able, by this time, to choose wisely the elective subjects desired. The student who has become particularly interested in any one field may elect subjects applying to that field; and he who desires a more general training may select courses which will broaden his outlook upon the several fields.

We have not as yet outlined a fifth year, but a fifth year might well be added. In this year much of the work might well be elective, and possibly an M.S. degree given upon its completion. On

* Mechanical Engineering 265, Internal Combustion Engines, may be substituted.

† Math. 322, Differential Equations, may be taken by qualified students.

the other hand, one could obtain a B.S. degree in a specific professional engineering course.

The course as outlined doubtless has its flaws and imperfections. It has been necessary to make selections, in most cases, from existing courses. Most of these are fairly well suited to the demand of General Engineering, but some few of them are not. Difficulties in scheduling have frequently been encountered, and some subjects have had to be eliminated on this account. On the whole, however, we believe the work to be fairly well balanced and to contain excellent basic training.

It has not been our purpose to supplant any of the other professional courses, but rather to supply a real need. We do not wish to influence any student who has already made up his mind to pursue a certain definite line of work. We believe, however, that there is a sufficient number who wish the general engineering knowledge as equipment for specialization and further study to warrant its inception. These are the students in whom we are especially interested. Considerable care has been exercised to keep the requirements on a par with those of any other school and, naturally, we do not wish to attract those who have failed somewhere else. We sincerely believe that the work as herein outlined will prepare our graduates for valuable service in the engineering profession and will give them a splendid outlook upon many of the world's problems.

THE SCHOLARSHIP COMMITTEE AND ITS PROBLEMS

By R. C. WRAY

Instructor in Civil Engineering, University of Arkansas

Introduction

The information presented in this paper concerning the methods of administering scholarship deficiency cases has been obtained directly from fourteen representative engineering schools in the East, Mid West, and South. I sent a questionnaire to sixteen schools and nearly all co-operated by answering. Schools contacted were: M. I. T.; C. I. T.; Rose Poly Tech; Cornell; Michigan; Wisconsin; Purdue; U. of Tennessee; Kansas State; Penn State; V. P. I.; Texas A. and M.; Ohio State; and Georgia Tech.

Thirty-three per cent of all students enrolling in freshman engineering are eliminated due to scholastic failure. Ten per cent more possibly are scholastically deficient at some time but finally graduate. Proper treatment of these forty-three per cent is the

chief problem of the scholarship committee; however, greatly we disagree as to what constitutes proper treatment.

Variations in type, personnel, and function of scholarship committees are numerous. The committee may concern itself entirely with standards of scholastic achievement to be maintained and have no contact with students whatsoever. Scholastic standards and status resulting from failure to meet minimum requirements are given out upon entrance and the student serves as his own counsel until elimination or graduation. Another type of committee serves as the official boot by means of which students are kicked out or placed on probation. The laws are laid down, but the committee affirms their validity for each offender. The most common type is the jury committee which interviews, cross-examines, reprimands, advises, and punishes, but gives special consideration to each delinquent and varies the law to suit the need.

A more uncommon type of committee is one that concerns itself chiefly with prevention of scholastic failure by serving as friendly counsel and confidante. It usually operates as an extensive adviser system and includes most of the faculty. Students have as an adviser usually an instructor with whom they are well acquainted. The other types of committees may consist of one or several men who often are total strangers to the student. The advisers are usually supplemented by a group to pass final judgment when necessary. The problems of the committee will vary widely with its functions, and the basis upon which a scholarship committee should be organized is a point for discussion.

The decision as to who shall be considered scholastically deficient and as to what shall be done with them is assumed as the problem of the scholarship committee. The bases for determination of deficiency vary widely with different institutions. There seem to be about four methods used, as follows:

(1) Failure in a specified number of hours or courses.
(2) Failure in a specified percentage of hours carried.
(3) Failure to pass a required number of hours.
(4) Failure to show a certain quality of work as indicated by average grade for all courses.

Another approach entirely is to consider all who have a tendency to scholarship deficiency as indicated by low high school record, low intelligence or placement test grade, or any early evidences while in college that low grades may soon be expected. The adviser system working for a prevention rather than a cure follows the above mentioned procedure quite often.

Three degrees of delinquency are usually recognized. These are:

(1) Students to be warned or advised.
(2) Students to be placed on probation.
(3) Students to be dropped from school.

It is rather difficult to compare policies on this matter because of variations in method of determination of deficiency and variations in grading systems. Warning is omitted in most schools while others warn on failure of a single subject. One school warns only when 40 per cent of work is below passing grade. Probation is customary with nearly all schools although the advisability of using this treatment is not accepted by all individuals. Only M. I. T. of the schools studied has no probation but it gives "black marks" for inferior quality of work. The extremes in probation standards seem to be as follows:

(1) Low; failure in 50 per cent of work or failure to pass 10 hours work.
(2) High; failure to maintain an average grade between C and D, D being a passing grade.

Most schools are more lenient of freshmen than upper classmen. Allowable periods of probation vary from one semester to an indefinite period.

Dismissal from school usually results from either of two classes of failure: first and most common, continued low grades after being placed on probation, or second, very poor grades for a single semester. The standards for dismissal of students on probation are either the same as for probation or even higher in several schools. Probation and dismissal may be entirely automatic; theoretically automatic but not practically so, or standards may be varied considerably in each specific case.

Treatment of scholastically deficient students may be formal or informal. In the formal treatment rules and regulations are imposed on probationary students. Some adopted practices are:

(1) Barring the delinquent from all extra-curricula student activities.
(2) Requiring student to report to committee or adviser at stated intervals for check-up.
(3) Posting names of delinquents.
(4) Reducing scheduled load of failing students.
(5) Requiring extra periods of work or special tutoring.
(6) Requiring teachers to report grades oftener than usual.
(7) Reducing or eliminating allowed number of absences.
(8) Most Important: Requiring an immediate improvement in quality of work performed.

Formal treatment is usually accompanied by automatic or semi-automatic methods of grading deficient students.

Informal treatment is usual with the adviser system of dealing with delinquents. This treatment depends on the reason for failure which it may or may not be possible to determine by having the student appear before a group or by having him confer with a single individual.

Reasons given for failure in *Bulletin No. 2* of the *Report of Investigation of Engineering Education* are as follows:

(1) Failures due to lack of ability or lack of interest—51 per cent.
(2) Poor preparation—15.6 per cent.
(3) Self support—8.1 per cent.
(4) Social and fraternity activities—5.7 per cent.
(5) Poor health—4.7 per cent.
(6) Undergraduate activities—2.8 per cent.
(7) Entrance conditions—2.7 per cent.
(8) Other causes—0.5 per cent.
(9) Unknown causes—8.7 per cent.

If these be the real reasons for failure, then formal treatment combined with automatic probation and dismissal seem almost adequate. Classification of reasons for failure may be entirely different from the above as follows:

(1) Improper study methods.
(2) Lack of adequate training in fundamentals in high school.
(3) Uninteresting, inefficient, and unsympathetic instructors.
(4) Improper environment.
(5) Procrastination.
(6) Mental and emotional conflicts, due to family life, homesickness, financial difficulties, religious problems, feelings of inferiority, and love affairs.

The adviser plan, concerning itself chiefly with remedial action, must necessarily work on reasons similar to the last group as basis for proper treatment and adjustment.

Conclusions

From my brief study of the problem and my inadequate experience in actual dealings with deficient students, I have drawn the following conclusions:

1. The best plan is the adviser system combined with committees including the entire faculty.

2. Appearances before a single individual is far superior to appearances before a group; therefore, a single adviser should confer with the student.

3. What students should be considered scholastically deficient and the proper action or treatment to be made in each individual case should be the result of careful thought and discussion in the faculty committee meetings where the combined opinions of the students' instructors and of those experienced in dealing with failures may result in effective and speedy recovery of the student to normal standing.

4. Probation as a punitive measure is of little value.

5. Interviews between the deficient student and his adviser should occur at intervals not greater than two weeks and should be of entirely informal nature.

6. The adviser should have a complete scholastic record of each student. This should include high school record, intelligence test ratings, and complete college record. He should also have a personal record derived from observation and from contacts with acquaintances of the delinquent student.

7. Advisers should obtain every two weeks from all instructors data on scholastic work, attendance record, interest taken, attitude shown, and effort put forth by the failing student.

8. Formal report covering the interviews with the student and the instructors' records should be made by the adviser to the faculty committee at stated intervals.

9. Immediate treatment should be started for students admitted with low high school grades, low intelligence or placement test rating, and on others whose high school records show a very minimum of credit in the fundamental base courses.

10. Treatment should concern itself almsot entirely with remedial action; however, absolute lack of coöperation and continued failure should result in dismissal.

11. If lack of interest seems genuine, aid should be given in finding proper field of endeavor.

12. If lack of ability is clearly evident, action should be as speedy and as painless as possible.

13. Low quality of a student's work is a better index of failure than the number of hours below passing.

14. Progress charts, showing each student's attendance, grades, and percentage of written work completed, when posted for all students to see are very effective in reducing number of failing students who have to be eliminated by official action.

15. The student's best interests should be of foremost importance in all action taken.

Illinois-Indiana Section.—On April 6 members of the engineering faculties of Armour Institute, Purdue University, Rose

Polytechnic Institute and the University of Illinois met at Purdue University, Lafayette, Indiana, and took formal action toward organizing the Illinois-Indiana Section of the Society for the Promotion of Engineering Education. A constitution was formally adopted and the following officers elected.

President—Joseph B. Finnegan, Professor of Fire Protection Engineering, Armour Institute of Technology.

Vice-President—R. B. Wiley, Professor of Sanitary Engineering, Purdue University.

Secretary—T. C. Shedd, Professor of Structural Engineering, University of Illinois.

Executive Committee—Officers: Prof. J. C. Peebles, Armour; Dean H. H. Jordan, Illinois; Prof. F. L. Serviss, Purdue; Mr. H. N. Chinn, Rose Poly.

Following the election of officers and the adoption of the constitution, the Secretary was instructed by vote of the convention to make formal application to the national society for approval of the Illinois-Indiana Section.

T. C. SHEDD,
Secretary

Morning Session 9 to 12

Call to order by Dean A. A. Potter, Temporary Chairman.

Organization of Section; adoption of constitution; election of officers.

Address: *The Engineer and the Public Service.* Judge Sveinbjorn Johnson, University of Illinois.

Address: *Laboratory Instruction in Engineering Education.* Prof. J. O. Draffin, University of Illinois.

Address: *Training in Economics for Engineers.* Prof. H. P. Dutton, Armour Institute of Technology.

Afternoon Session 1 to 4

Conferences

The Teaching of Chemical Engineering. R. N. Shreve, Chairman; J. L. Bray; D. B. Keyes; Harry McCormack.

The Development of Inventive Ability. G. M. Bartlett, Chairman.

The Place of Electronics in the Electrical Engineering Curriculum. C. S. Roys, Chairman; H. A. Moench; H. J. Reich; J. S. Thompson.

Model Testing, Dimensional Analysis, Hydraulic Similitude. F. B. Seely, Chairman; W. E. Howland.

The Teaching of Soil Mechanics. Herbert Ensz, Chairman; E. E. Bauer; Albert Jorgensen.

English for Engineering Students. H. E. Babbit, Chairman; W. B. Fulghum; F. W. Greve; Walter Hendricks; J. H. McKee; C. C. Olson.

Organization Committee:

M. L. Enger, Illinois,
J. B. Finnegan, Armour,
H. T. Heald, Armour,
H. H. Jordan, Illinois,
O. A. Leutwiler, Illinois,
H. A. Moench, Rose,
J. C. Peebles, Armour,
R. B. Wiley, Purdue.

(As adopted)

CONSTITUTION OF THE ILLINOIS-INDIANA SECTION

Article I. Name.

The name of this organization shall be The Illinois-Indiana Section of the Society for the Promotion of Engineering Education.

Article II. Objects.

The objects of the section shall be the promotion of the highest ideals in the conduct of engineering education with respect to administration, curriculum, and teaching work and the maintenance of a high professional standard among its members.

Article III. Membership.

Membership in the section shall be open to all members of The Society for the Promotion of Engineering Education residing in the states of Illinois or Indiana.

Article IV. Officers.

The officers shall consist of a president, a vice-president, and a secretary.

Article V. Executive Committee.

There shall be an executive committee consisting of the officers and of one member from each of the colleges in the two states which holds institutional membership in The Society for the Promotion of Engineering Education. The president of the section shall be chairman of the executive committee.

Article VI. Annual Meeting.

The executive committee shall arrange for an annual meeting and prepare a program for it. These meetings shall be open to all persons interested in engineering education.

Article VII. Election.

The officers and the members of the executive committee shall be elected annually at the annual meeting. They shall take office at the close of the annual meeting at which they are elected.

Article VIII. Amendments.

This constitution may be amended by a two-thirds vote of the members present at any regular meeting of the Section.

A LAWYER LOOKS AT THE ENGINEERS

By JUDGE SVEINBJORN JOHNSON

University of Illinois

I believe this organization has dedicated itself to the praiseworthy object of promoting engineering education. In departing somewhat from the general topic on which I was asked to speak, I have nevertheless recognized fully, I hope, the inescapable fact that the engineer, no less, but usually very much more so, than the average citizen, is subject to a certain public responsibility by virtue of his professional training. He is a trustee of a fund of specialized knowledge, and, later, of specialized experience, which he holds and husbands not only for his own, but, in a large degree, for the public benefit. Without a full realization of this simple fact the engineer is bound not only to fail in the performance of his duties as an ordinary citizen, but to fall short of a full accounting to one of the principal beneficiaries of free public education, the public itself. I am more and more impressed that we, who have some share of responsibility for the processes of education, cultural and professional, fail our students to the extent to which we neglect the point of view that the educated man is a trustee who owes an accounting in the form of good citizenship, to the public which has made his training possible.

I emphasize at once the special nature of the engineer's responsibility as a quasi public servant, like the lawyer and the doctor, because if that is ignored or denied, you forfeit your claim to professional standing, and your public obligation becomes simply that of the average citizen, to discharge the franchise and, when called to public office, to perform its duties in a conscientious way.

In our complex modern industrial life, in an age when the government is steadily, under the pressure of public demand, extending its activities into fields heretofore considered the special domain of private enterprise, the opportunities and the obligations of the engineer—I use the term in a broad sense—suggest distinct

problems to those who are responsible for educational theories and methods.

The relation of law and medicine and some other specialized activities to the public render those who practice them quasi public servants. These callings have been recognized by our legislatures and by the courts as so intimately affected with a public interest that for centuries no informed lawyer or medical man but knows and admits that the practice of his profession is not a right, but in the nature of a privilege which the State may withhold or take from him upon any reasonable grounds. In short, in these fields the primacy of the public interest over what might, superficially viewed, be termed individual rights, has long since become one of the fundamental principles of that branch of the law which regulates the vocations by which mankind earns a livelihood. If the engineer hopes to attain professional standing, in the sense in which law and medicine have attained it, he can achieve it only at a certain price. If you are not willing to pay the price professional status demands, in the form of generous recognition of a high degree of public responsibility as the trustees of specialized knowledge, you will not soon rise above an honorable group of well trained and competent craftsmen, artisans and designers—the historical antecedents of the modern engineer.

What are your antecedents? Until about the year 1800, the major activity of the human race, civilized and savage, unfortunately, had to do with war and the preparations for war. It was not much before 1750 that the engineer who devoted himself to the arts and practices of peace appeared upon the scene. Up to that time the engineer was mainly the chief lieutenant of the warlord, whose plans were carried out by soldiers; and after 1750, or thereabouts, the engineer, whose work was carried out by or under the direction of civilians, began to win a foothold in the world.

I have spent much time and endeavor, not with complete success, as I view it, in trying to discover a statement descriptive of the engineer, of his function in society and of his characteristics which would help me to differentiate him from other human beings who do, or are willing to do, something for a living. I found a description, which I understand is considered famous in engineering circles, in the charter of the Institution of Civil Engineers in London in 1828, where civil engineering is said to be "the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, acqueducts, canals, river navigation and docks for internal intercourse and exchange, and in the con-

struction of ports, harbors, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce and in the construction and adaptation of machinery, and in the drainage of cities and towns."

It is my understanding that civil engineering is now merely one branch of engineering. If that be so, either the description I have quoted is a trifle comprehensive, or else much specialization, with consequent narrowing of terms, has taken place in the century since it was framed. To the layman from the outside it appears doubtful that a being—it does not follow that he is rare upon this earth, merely because I have not encountered him—whose aspirations, may I say pretensions, to knowledge, are so nearly universal in their scope, is likely soon to attain comfortable professional standing. Such a "profession" could be planned only with the purpose the old lady admitted when taxed with too large expectations in putting two dozen eggs under biddy: "I just want to see the darn thing spread herself."

It seems to me, however, that I have heard of specialties in engineering. There is mechanical engineering, which, at least historically, had to do with moving machinery, steam engines, tools and the like; there is mining engineering which probably branched off next, which, historically, concerns itself with the location and the working of fuel and mineral mines; then probably came naval architecture; then marine engineering, having to do, among other things, with engines propelling vessels on the high seas; next, perhaps, sanitary engineering, concerned historically, with the problems of wholesome water supplies for communities; then gas engineering appeared on the scene, to be followed by chemical engineering, the principal objective of which seems to have been the designing of plants for the manufacture of chemical products and in working industrial processes; then electrical engineering, now one of the very important branches of this great subject, and also the heating and ventilating engineer. We have, likewise, highway engineering, a rapidly developing science because of the tremendous attention to improved roads, due to the development of motor vehicle transportation. I have not forgotten military engineering, from which, like flakes, these specialties have fallen, or railway engineering; then I must not forget agricultural and ceramic engineering, general engineering, and engineering physics. I have heard of the industrial engineer, sometimes, more or less lightly, referred to as the "efficiency expert," and I think I have also heard of social engineering, but what its scope may be, I am not competent to suggest. I am sure I have overlooked some types of engineering, but I have perhaps mentioned enough to remind you of your "infinite variety."

I do not question the claim of at least some branches of engineering to professional standing. That claim, however, raises at once the question, what are the basic principles of engineering education and of engineering practice? I am not vain enough to think I can supply an answer this morning, or unwise enough to attempt it. I raise the question because, unless you find such basic principles, you cannot, it seems to me, work out a curriculum of engineering education which will support either the claims of our engineering colleges to the classification of real professional schools, or the desire of their graduates for professional standing.

Some questions occur to the layman, which to you may seem naive. Going back to the charter of the Institution of Civil Engineers of London, and assuming the essential soundness of its description of the engineer, is it not basic to any sound curriculum of engineering education that one of the functions of the engineer, as a specialist or as a professional man, is to direct, supervise, improve and adapt the application of the mechanical to the needs and uses of human society? The great discoveries in the realms of electricity, of chemistry and of physics remain nothing but interesting theories until a practical application is made of them through mechanical devices put together, operated and used by and for man. Is it not true that otherwise these inventions and discoveries are quite useless?

Must not one of the basic aspects, one of the very fundamental principles of the engineer's educational curriculum, have much to do with the mechanical, the laws of mechanism, if there be such, using the terms in the broadest sense? To illustrate: Gas and electricity possess certain properties which experiments in the laboratory disclose. These properties, however, have nothing more than an academic significance to human society until their various manifestations, through almost innumerable devices made by man, have been made useful to and put under the control of human beings.

Another side of the picture, and I again simply raise the question, is that there is no need for the mechanical until the formula or the property has been discovered in the laboratory. The electric motor and the gas engine obviously could not be discovered and put to practical use until the properties and the control of gas and electricity were known and understood. I shall not attempt to answer which comes first, the hen or the egg, the mastery of utilitarian mechanics or the discovery of principles and properties of force, or matter. I simply raise the question, because, unless you can find an answer and evolve a curriculum based upon some basic or fundamental principles, which can be regarded as elementary or foundational when you are considering any field of specializa-

tion in engineering, are not the difficulties of a solution rather staggering when we contemplate them? As a layman, I raise the question whether you do not need to redefine engineering, eliminate and reclassify, unless you hope to found a profession of virtually universal knowledge. The layman, looking at our engineering college catalogues, in his ignorance and insophistication, wonders whether you have anything more than a confederation of specialties.

By referring to a field in which, presumably, I have a little knowledge, that of the law, perhaps I can make clearer what I am trying to say. Not very long ago the lawyer was looked upon simply as a pleader in court. That is why the lawyer was often described as an advocate. He was called to plead the cause of another. Most of the disputes, in the formative period of Anglo-Saxon jurisprudence, grew out of the violation of contracts or of tort cases where one individual inflicted an injury upon another, or of the refusal to recognize the rights of another in land. The rules of the law governing agreements and fixing the rights of individuals against injury from their fellows grew up through long centuries of human association and came to be accepted as desirable rules of conduct in the interest of communal peace and amity.

The machine age came, with all the inventions of new machines and new methods of doing business, with new conditions of employment, with new situations in which contracts between persons were made, and with factually new relations into which human beings were thrown. All these were unprecedented because unprecedented mechanical inventions and scientific discoveries brought them about. Nevertheless, the old principles of contracts, the old rules governing the rights and the obligations of individuals living together in human society, were just as applicable as before. True, the application of them was extended to new fact situations, but the underlying and governing principles were still fundamentally and essentially the same. In spite of changes in industry, changes in machinery, the revolutionary discoveries of science, the complete overthrow of everything old brought about by the industrial revolution, these fundamental principles remained unchanged save in their application. The great cases, the difficult problems in the law and to some extent, at least, in medicine have to do with the *application* of the *known* more than with the discovery of new rules or principles.

Can you, without finding fundamental principles and making them basic in courses of instruction, somewhat upon the analogy of law and medicine, have true professional schools, true professional men, on a basically unified program of education? Medicine cannot, accountancy cannot, certain other specialties cannot. Can the engineers? I ask the question, not in any spirit of doubt,

but because I believe that until and unless you can find and state basic principles, you will have difficulty in winning for any branch of your profession, for any of the numerous "specialties," that distinctive recognition which their importance unquestionably deserves. Maybe you have already found these principles, which will stand firmly despite the restless flux of scientific and mechanical change; or perhaps your concept of what a profession signifies is different from and sounder than mine.

The law, of course, is not unaffected by the great discoveries of science and the arts. There is specialization developing in the law. We have the trial lawyer; we have the corporation lawyer; we have the counsellor who never goes into court; and we have the patent lawyer, but, except for the last named, we do not have every "specialized" group in a class by itself or in an association or society of its own. Without exception the basic principles, without a full understanding of which no specialist can succeed, are the same underlying all these specialties with a possible exception in favor of the lawyer who specializes in practice before the Patent Office in an effort to obtain monopolistic control of an invention for the inventor. That field is highly specialized, and a man may be a good patent lawyer in this sense although he understands very little about some of the basic principles of contracts or of torts. He may be the best man for the inventor to go to in order to obtain a patent, but after the patent has been obtained and when it is put into use in industry, and when contests arise over its use, then the lawyer who handles the contests must be versed in all the fundamental principles of the law, as well as in the scientific specialty involved in the invention.

Medicine, although there are specialties in the field, nevertheless is built around a body of principles and of knowledge which new discoveries do not wholly overthrow, scarcely even alter. Again I ask the question, is this true, can it be made even reasonably true, in the field of engineering, or in some of its special branches? Can you gentlemen work out and state some basic principles which will withstand the revolutions which the human intellect periodically stirs in the scientific and mechanical fields, which are underlying, and which are essential to permanent success in any specialty in engineering? Unless you can, will not the orthodox or traditional concept of a profession have to be revised before the multitude of engineering specialists can, as a single, and at present, as it seems, conglomerate group, fit into it?

It is not necessary, from my point of view, that the engineer shall forthwith be brought within the conventional category of a profession, in order to hold him to strict accountability for the proper use of the specialized knowledge of which he is the master.

In the old days, when the "chief engineer" was but the head man or foreman of a gang of carpenters, artists, smiths and the like, the service he rendered to his king and to his country was, relatively speaking, scarcely less important than the services of a Goethals, or of any one of a dozen of the great names in engineering.

It goes without saying, as I indicated earlier in this address, that the importance of the engineer in the governmental service is steadily increasing and that there will be no diminution of his importance in this behalf. His services will be invaluable in countless instances with reference to estimates, contracts, the quality and details of construction, in the case of enormous enterprises of incalculable importance to the people for generations to come, both from the standpoint of initial cost and the durability of construction. We have been told so often that I hesitate to refer to it, that the patient who entrusts himself to a physician has faith beyond compare, and that correspondingly, the man in whom this supreme trust is laid has a responsibility which can scarcely be exaggerated in words; it has also been as often and as tritely said that the man who entrusts his property interests, his liberty, and sometimes his life, to the hands of a lawyer, puts faith in him in the here as great as is his faith in his God in the Hereafter. Obviously the man who is faithless to the trust which is reposed in him as a professional man in the circumstances I have mentioned is beneath the contempt of honest men. Human faith, human confidence, human trust of this kind can scarcely go farther. Yet, is not the faith of a whole people in the ability and in the integrity of the engineers who design and construct such monumental works as Boulder Dam, upon the essential integrity of which depends not only an investment of hundreds of millions of dollars of public money, but the lives of countless human beings, worthy of even greater reverence than is the trust of the patient in his physician or of the client in his lawyer? I unhesitatingly answer, Yes.

The engineer in the public service, aye, even in the private service, is a recipient of a trust, is a donee of a responsibility unexcelled in importance by anything within the experience of the greatest physician or the greatest lawyer. Whether the engineer be technically or conventionally a professional man, or something else, is rather unimportant. He has become an indispensable executive of every major detail of any sound program of human progress. Without the engineer, the great discoveries of science would lie dormant in the laboratory, the useless subject of academic speculation and debate. His function, it seems to me, is to prepare and state formulas, to select or create methods and devices for and generally to supervise the translation of the discoveries of science

into instrumentalities of social use. His position in society is clear; his responsibility to society is even clearer.

Can we teach this in the schools? Is this all a matter of education in the sense of imparting knowledge, or is it a matter of attitude, in the sense of a sound outlook, a fair appreciation of personal responsibility which grows in direct proportion to the increase of knowledge? I think it is the latter. It is of course obviously indispensable, a fact which has been recognized by some engineering colleges, that hte engineer shall go forth equipped with an understanding of the fundamental principles of our constitutional government; of contract law; of the law of damages and of torts; of the essential importance of care in the drafting of all agreements and particularly contracts involving great enterprises; and above all, that he go not forth in the conceit that because he has pursued courses in these subjects he knows them; rather that he go out into the world with a sound awareness of his limitations, but with enough knowledge of the law to recognize a serious legal problem when he sees it and thus take it to the specialist in the field instead of attempting to act as lawyer and engineer combined.

I am glad to see Purdue establishing coöperation between its engineering faculty and the law faculty at Bloomington. There is no such thing as engineering law, any more than there is engineering English, or engineering integrity, or measles peculiar to engineering, as distinct from law or English or personal honesty or any kind of measles. I have never been able to see any excuse for the absence of coöperation between a law school and an engineering school on the same campus. All law should be taught by men trained in the law, and this is true whether a man goes into a bank, into other business, or into engineering; and if English belongs with the cultural subjects, your students should not be required to pursue it as a part of an engineering course, any more than law or medical students take it as a part of their professional courses. There is here a lack of correlation and cultural foundation which should be corrected.

We are lacking in this country in a spirit, or in an attitude, as I prefer to call it, which holds the conscience of the public servant constantly alive to the fact that the public, although invisible, intangible and immaterial because infinitely dispersed, is nevertheless just as definitely his employer as is the ordinary individual or corporation. It is the attitude that the public business is nobody's business, that when you serve the public, you are not serving a master, and because the public does not stand around with an implied threat of discharge it is non-existent as an employer, which accounts for the waste, the extravagance, the indifference, the downright dishonesty which so often creep into the public service.

It ought to be possible in a series of lectures in the more advanced curriculum to bring out an attitude in the engineering student which as a graduate will render him a more faithful and a more conscientious public servant.

In England the public service is looked upon as in the nature of a profession, a calling, or a career, and men take pride in it and endeavor to perform their duties with more scrupulous honesty and regard for the public welfare than often characterize like services in America. It is not because our people are essentially less honest than Englishmen. It is rather that we are brought up, educationally speaking, in a different way and somehow we do not acquire the attitude towards the public service which marks the thinking processes of the Englishman.

I doubt if it is possible to teach morals successfully in any professional school. Integrity, using that term in its broadest sense, is a gift of the gods. It is like that indefinable and uncommon thing we call common sense; it cannot be taught, or acquired. I am, therefore, particularly glad that your organization considers the selection of students as well as the kind of instruction they shall have when you have them in the schools. One of the great weaknesses of the law and of medicine lies in the inability to prevent the fundamentally dishonest young man from entering the school as a student; another difficulty lies in the fact that his moral unsoundness can rarely be discovered except by chance, even after spending three or four or five years as a student.

In closing, may I raise one more question. Has not the time come when a degree in engineering will not be conferred except upon the completion of at least two, preferably three, years of general college or university training? Law and medicine have not only come to this point but passed it. Can you build a sound structure of specialization in general engineering without a broad foundation of cultural education? Rightly or wrongly, law and medicine have concluded that such specialization is not possible without a liberal education as a prerequisite.

LABORATORY INSTRUCTION IN ENGINEERING EDUCATION

By JASPER O. DRAFFIN

Associate Professor Theoretical and Applied Mechanics, University of Illinois

As all of you know, changes of large magnitude in educational ideas and ideals appear to be on the horizon and these will affect engineering as well as general education. Some people believe that

laboratory work will be affected. I shall discuss the *past, present* and *future* of laboratory instruction.

Past.—The early manner of teaching in this country was mainly by lecture and recitation but somewhere about 100 years ago Amos Eaton introduced the laboratory method at Rensselear Polytechnic Institute. The new idea was adopted by other institutions and proved most effective in stimulating new ways of thinking and in helping to uncover a vast body of physical facts which played their part in the oncoming scientific and mechanical age. Probably our remarkable scientific advances would never have been achieved had the students of science and engineering not been instructed in laboratory methods and in the proper ways of analyzing and interpreting data and in reaching sound conclusions.

It is important to note that Eaton conceived laboratory work differently than we do today. He thought of it more as a symposium in which "they [the students] are to lecture and experiment by turns," instead of writing reports about their work. This symposium type of teaching has the marked advantage that it causes one mind to play upon another and so stimulates both the speaker and the hearer as well as subjects the propositions put forward to a critical examination. Such a proceeding is decidedly different from writing a report, valuable as that is, since the report does not involve the reaction of other minds upon that of the writer in the presence of the real situation. In substituting report writing for reporting, we have mislaid a great educational idea.

Present.—As time passed, the schools, colleges and universities were called upon to teach increasingly large numbers of students, mass production we sometimes call it. With large numbers of students, the instructors, equipment and laboratories must be assigned and used with clock-work precision and this, together with the fact that the engineering field has increased so greatly, leaves less opportunity than formerly for the individual student to work as his inclination and spare time dictates. Then, too, some of the more elementary laws of action of and facts about machines and materials, which were partly or wholly unknown when laboratory instruction began, have become common-place knowledge and may be found in all handbooks and textbooks. As a consequence of these three things, large number of classes, more subject matter to cover and less of the element of surprise or discovery, the student is no longer an explorer, delving into the unknown with all the zeal, delight and fervor which youth possesses in its search for adventure, discovery and truth. Instead the laboratory exercises, for the undergraduate, have become more and more a process of repeating a series of experiments or exercises the results of which are well known to the student before he begins the experiment.

The whole process has become more of a mental and skill *discipline* than of a mental *stimulus* or *incentive*.

These changes have made the experiments more of a stereotyped affair and removed from them much of the life and zest which they formerly had and writing reports on these experiments is even less inspiring. Everyone, students and instructors, knows that ordinarily no use will be made of the data obtained by the student, whether the test be of the performance of an induction motor, the efficiency of an air compressor, the coefficient of friction in a water pipe or the strength of a piece of structural steel. In other words, the experiment, exercise or test is purely routine and therefore is not likely to arouse much interest in the student. Under such circumstances the tendency is for the course to become "cut and dried," both to student and instructor, and lacking in interest and consequently in educational value to the student. Note that I say *tends* to become "cut and dried" and not necessarily that it has become so.

At the University of Illinois the faculty of the College of Engineering, through a number of committees, has been studying educational policies and methods for nearly two years. A student questionnaire supervised by one of the committees confirmed what we had already thought to be true, namely, that the laboratory courses required more time from the student for each credit hour than the recitation, quiz or lecture courses. It was clear that this excess time was mainly due to the time required to write laboratory reports. By modifying the content of the work and the writing of reports this excess time has been much reduced in some of the courses.

The things enumerated above have been partly responsible for, or at least they have not helped to lessen, the feeling which has been growing in a number of quarters that laboratory instruction does not have as much educational value in it for the time, money and effort expended as some other forms of education. A reaction seems to be growing against the "learn by doing" method. One of our well-known philosophers, Professor Hocking, has said recently that;*

"There is something going on in philosophy which bears on education . . . it will require at least a radical revision of the slogan 'Learn by Doing,' which has become almost the chief characteristic of American education. The effort to impart action . . . for each step in learning was a mistake; . . . it interferred with the development of that mental power which nature gave to man as a substitute for universal activity, his imagination. . . . Learning by doing . . . is the sub-human method of learning, animals must learn that way . . . they cannot live in the world of ideas. But man can . . . and enjoy it."

* *Harvard Alumni Bulletin*, Nov. 3, 1934.

Many other utterances from various source sexpress doubt as to the effectiveness of substituting doing for thinking.

Since costs have been mentioned, the question may be asked as to the cost of laboratory work. At the University of Illinois we require 136 hours of academic work for graduation and of the 136 hours our students devote 20 to 30 credit hours to laboratory work, in other words about one-fifth to one-quarter of the work done by the student toward graduation is done in the laboratory. Since it costs from two to four times as much per student credit hour to teach laboratory as to teach lecture or recitation, it follows that the instructional cost for laboratory work is from one-third to one-half the entire instructional cost of the engineering student. Is there any justification for giving such a large proportion of high-priced laboratory courses, high-priced in the time of the student and in the cost of instruction, unless the educational return to the student is worth it?

It may seem strange that one whose work is to a considerable degree teaching laboratory should raise such questions, but the questions did not originate with me. Furthermore you may rest assured that they will be raised by someone and that in the not far-distant future. The point I am making is that we should improve laboratory instruction if study shows that it is not as effective a teaching element as it should be. I fear that at present many exercises are merely tasks to be performed according to a prescribed method and reports written. There is lacking that inspiration, that enthusiasm which is present in the work done by a student who is at work at least partly under his own initiative.

Future.—Not long ago the graduate engineer was in constant demand, industry needed engineers in large numbers, *quantity;* that period is past and the demand is now for *quality.* This naturally requires quality teaching and especially in the laboratory where students should be able to discover themselves. If conditions are even approximately as I have outlined them, what shall we do about it? In order to plan wisely we must have a clearly defined objective and see where the elements contributed by laboratory work fit into the scheme. How shall we define education? For our present purpose I would say that education consists in the growth of the thinking processes. For this growth to take place the student must have *something* to think *about,* he must have a *scheme* or manner of *thinking* and he must reach some kind of a *conclusion.* I am fully aware that my definition is quite inadequate, that it leaves out of consideration that most important phase, the education of the soul or spirit, that which for want of a better name we call culture or character, and that my answer considers only the mental capacity. But since I cannot cover

everything in this paper and since culture is not the result of any particular course, I have restricted myself to the intellectual aspect. Education for the engineering student differs from that for others mainly in the things he thinks about, the tools he uses to think with and the ease with which he can check his conclusions. In the process of obtaining an engineering education the student must somehow achieve the ability to visualize engineering works in the midst of their surroundings, acquire sufficient technique or skill so that he knows the degree of accuracy which can be attained or which may reasonably be expected, cultivate analytical ability, possess intellectual honesty, and have a fair degree of initiative, imagination, perseverance and self-direction. How does the laboratory help the student to accomplish these ends?

Naturally, the specific objectives in any course, such as those in a vacuum tube laboratory, will be different from those in some other course, such as a metals heat-treating laboratory, but in all these there must be something to observe and to think about. There should be some common core for all laboratories. This common core consists of two more or less distinct kinds of work, overlapping somewhat but usually with one element predominating. These two kinds of work are (1) observation of phenomena, and (2) analysis of results. In the first type, observation of phenomena, we have two liquids put together and a precipitate is observed to form; or light is passed through a prism and a spectrum is observed; or a bar of steel is pulled into two pieces and it is observed to elongate appreciably before it breaks; or a steam indicator diagram is drawn and the varying pressure in the steam cylinder is observed. Such observations supply the student with a clear picture of what engineering machines and materials are like, qualitatively at least. This, then, is the thought material for the student. Closely related to this is the invaluable aid which laboratory work offers in cultivating accurate observation because of the positive check which it affords at many points. For instance, a student may make a short circuit on a wiring diagram and not know it but if he makes that mistake in the laboratory his error is recorded instantly in a definite and unmistakable manner and so it is with other problems; he has a clear, objective and immediate understanding of the situation. Usually the observed data must be analyzed but observation of phenomena is the basic aim.

The second type of laboratory work emphasizes analysis of results rather than observation of data. In this the student makes observations and from the data plots curves for the operating characteristics of a centrifugal pump, for the efficiency of a gas engine, for the tractive power of a locomotive or for the losses in a transformer. Here again observations are made but they are

secondary to the objective of finding out how the machine operates from the point of view of an economical unit in the industrial world.

I have tried to show how the laboratory furnishes the student with material to think about and how it creates and builds the tools and skills with which to think. Now what of the final result, the conclusions which he reaches? Does our present laboratory procedure and report writing lead to the habit of accepting responsibility, of coming to grips with the situation? This is only another way of asking whether our present methods of laboratory instruction tend to improve the initiative, the creative imagination and self-direction of the student. But is there any real reason why both these types of experiments, observation of phenomena and rating curves, should not produce all three kinds of educational results? If sufficient thought is devoted to every test, every exercise, it would seem that results might be obtained which would increase the amount of self-assertion and originality which each student has. At present all students observe almost endless amounts of data and in a way analyze them, that is in a perfunctory way. But not as many form habits of self-guidance either as to carrying on their own work independently or as to forming definite clear conclusions and accepting responsibility.

Are we as teachers accepting responsibility and furnishing the right kind of teaching and leadership? May it not be necessary for us to change our views in order to achieve the best results? Should laboratory work not help to orient and inspire as well as to instruct the student? It seems to me that unless at least a few of the students go out from the laboratory feeling that they have explored some small field of knowledge that they have missed something, something which is not in the content of the course but in the quality of it. Often an experiment which is routine in character may be given quality by pointing out that it, or some modification of it, has recently been used in industry or construction. A standard test of steel has been made more of a living thing with some students by discussing an unusual application of it or a practical test which has been made to supplement, extend or replace the standard test. The calibration of an orifice in hydraulics can be given interest by reference to some power installation where the water must be carefully measured or an industrial process where the quantity of liquid flowing must be known accurately. Endless examples will suggest themselves to you. Furthermore, some of the most valuable experiments from the viewpoint of benefit to the students are those in which he makes a mistake and repeats the work. It is not the performance of a specified number of experiments or tests which determines the educational benefit to the

student; much more important is the amount of self-sustaining interest which has been aroused. Recently I read this striking sentence "Pupils are never taught by the teacher's bombardment against their closed minds." This is true whether the bombardment is with physical experiments or words.

Is it not possible so to organize our work that we shall be able to inspire and then properly care for a few capable students who may be encouraged to select some phase of the work covered in the laboratory, but which is not on the regular schedule, and permitted to study it more intensively than in the regular course? His enthusiasm will be heightened and he will have the drive, the motivation which comes from working on a problem of his own selection. He may not get as good data, he may not cover as much ground, but what he does will be his own work. The educational benefit the student receives is at least partly conditioned by the intellectual curiosity which is aroused in him. It is not to be expected that every student will be enthusiastic about every subject but the remark of a student that "Course XYZ" is just "hooey" suggests that that student did not carry away any self-sustaining interest in it.

Briefly stated my thought is this: Laboratory work is a most powerful teaching tool, capable of producing large educational benefits, but it is expensive both in time and money. Due to a variety of causes it is tending to become less effective than it once was and it should be revised and changed in the light of present conditions.

To effect these changes the following five suggestions are made:

1. Laboratory work must produce intellectual stimulation if it is to be justified; it cannot be justified merely in order that the student may "learn by doing."

2. The more capable students should be allowed and encouraged to deviate from the regular schedule of a laboratory course and work somewhat as their interest dictates.

3. Laboratory work must have in it that quality of teaching which rises above mere performance. It must include the play of mind on mind for the instructor must lead the student to discover himself, a function for which the laboratory is admirably adapted.

4. We as instructors may need to change our outlook and reeducate ourselves to a new point of view; the instructor must discover himself.

5. Laboratory instruction must be regarded as one of the highest types of teaching and it should be accorded as much recognition, both financial and academic, as any type of instruction in the University.

Iowa-Wisconsin Section.—Friday and Saturday, April 12 and 13, middle-west members of the Society held meetings at Madison, Wisconsin. This regional conference was fortunate in having in attendance Dean C. C. Williams, the president of the national society. A total of 189 registered for the meetings, of which 127 were from outside of Madison. Faculty members from the following institutions were present: University of Wisconsin, Iowa State College, University of Minnesota, University of Iowa, Marquette University, Michigan College of Mining and Technology, University of Illinois, Armour Institute, University of Michigan, Lewis Institute, Milwaukee Extension Division of the University of Wisconsin, Northwestern University, and Notre Dame.

Dean O. M. Leland presided at the Friday afternoon meeting. The speakers were Dean F. E. Turneaure, University of Wisconsin; Professor G. W. Swenson, Michigan Tech.; Dean C. C. Williams, University of Iowa; Dean T. R. Agg, Iowa State College; Professor L. F. Van Hagan, University of Wisconsin; Professor E. D. Ayres, University of Wisconsin; and Dean F. A. Kartak, Marquette University.

The subjects discussed were "The Present and Future of the Society for the Promotion of Engineering Education," "Training Engineers for Public Service," and "Training for Administrative Positions in Engineering."

Friday evening a dinner meeting was held at the University Club. Professor C. D. Cool, of the Spanish department at the University of Wisconsin, acted as toastmaster. Glenn Frank, President of the University of Wisconsin, gave the principal address. Short talks were also given by men from the various institutions represented at the meeting.

Saturday morning was devoted to conferences of various groups interested in particular engineering subjects. The group conferences, which were attended by from 11 to 35 each, were as follows:

1. Drawing and Descriptive Geometry.
2. Shop Courses.
3. Chemical Engineering.
4. Metallurgy.
5. Electrical Engineering.
6. Heat Power Engineering.
7. Elementary Sanitary Engineering.
8. Hydraulics.
9. Mechanics: Laboratory Courses in Materials of Construction.
10. Mechanics: Statics, Dynamics, and Strength of Materials.
11. Topographical Engineering and Survey Camps.
12. Machine Design.

13. Industrial Engineering.
14. Engineering Problems.

A luncheon meeting was held Saturday noon at the Wisconsin Union. A special committee had been appointed Friday afternoon to report on the formation of a section of S. P. E. E. The report of this committee was heard and a decision was reached to form an Iowa-Wisconsin Section. The Committee reported a Constitution for the section, which was adopted.

The following officers for the section were nominated and elected:

President—F. Ellis Johnson, Iowa State College.
Vice-President—A. H. Holt, University of Iowa.
Secretary—J. B. Kommers, University of Wisconsin.
Executive Committee—F. A. Kartak, Marquette University; G. W. Swenson, Michigan College of Mining and Technology.

A resolution was adopted asking the Minnesota Section to make arrangements to merge with the newly formed Iowa-Wisconsin Section.

The visiting ladies were entertained Friday afternoon at the home of Professor R. S. Owen. They had dinner Friday evening at the Wisconsin Union, after which they came to the University Club to listen to the after dinner speakers there. Saturday noon the ladies had a luncheon meeting at the Wisconsin Union.

The next meeting of the Iowa-Wisconsin Section will be at Ames, Iowa.

Constitution of the Iowa-Wisconsin Section

Article I. Name.

The name of this organization shall be the Iowa-Wisconsin Section of The Society for the Promotion of Engineering Education.

Article II. Membership.

Membership shall be composed of all the members of the Society for the Promotion of Engineering Education residing in the States of Iowa, Wisconsin, and the Upper Peninsula of Michigan.

Article III. Objects.

The objectives of the Section are those of the National Society and the promotion of neighborly intercourse, friendly coöperation, and mutual help among its members.

Article IV. Officers.

The officers shall consist of a president, a vice-president, and a secretary.

Article V. Executive Committee.

There shall be an executive committee consisting of the officers and of one member from each of the colleges in the area which holds institutional membership in The Society for the Promotion of Engineering Education and which is not represented by an officer. The President of the Section shall be chairman of the executive committee.

Article VI. Annual Meeting.

The executive committee shall arrange for an annual meeting and prepare a program for it. These meetings shall be open to all persons interested in engineering education.

Article VII. Election.

The officers and the members of the executive committee shall be elected annually at the annual meeting. They shall take office at the close of the annual meeting at which they are elected.

Article VIII. Amendments.

This constitution may be amended by a two-thirds vote of the members present at any regular meeting of the section.

J. B. KOMMERS,
Secretary.

The officers for the **Kentucky Section** for 1935–36 are as follows:

President—L. E. Nollau, Professor of Engineering Drawing, University of Kentucky.

Vice-President—Samuel T. Fife, Professor of Electrical Engineering, University of Louisville.

Secretary and Treasurer—D. V. Terrell, Dean of Engineering, University of Kentucky.

SAMUEL T. FIFE,
Secretary.

A NEW COURSE IN THE ENGINEERING CURRICULUM

BY SAMUEL T. FIFE

Professor of Electrical Engineering and Head of Department, University of Louisville

In our dynamic civilization we observe changes of many types on every hand. As representatives of institutions which are affected by these changes and which also in reciprocal fashion cause changes, it behooves us to inquire deeply, and without an undue

bias, into the motions of which we are a part. In general terms we are educators and in a more restricted sense we are engineering educators. It is from this position that we should view the problems of life.

At the outset let us determine certain basic concepts. First, what should be the object of education in general, and second, what should be the object of engineering education in particular.

In my opinion the object of formal education in general should be to inform the individual of the various aspects of life as we find them here and to prepare him to reflect upon these facts in an intelligent manner. It is, thereafter, his concern to draw his own conclusions and to act as he sees fit. The scope of the task is large indeed. At our particular instant in history the fields of life are broad, the influences diverse, and many phases seem confusing. It should be the task of real educators to present the truth and the facts as far as our horizon permits—regardless of the ends to which they lead.

Stretching far beyond the limited domain of so-called "facts" (with which the engineer is familiar) lie green pastures of that which up to the present time appears not to have yielded to the efforts of mankind to crystallize it into forms which can be treated by the calculus, or weighed on a chemical balance, or placed in the general energy equation of thermodynamics. In this hazy corner of man's conceptions we find such matters as religion, philosophy, sociological questions, psychology, and etc.

We may from this brief picture divide human thought into two divisions; first, the "concrete or factual," and second, the "intangible." It is not my purpose here to enter into bullet-proof definitions, nor do I hope to avoid charges of incompleteness concerning some of the material involved but it is my hope that the general idea will be clear.

In the first division, the "concrete," we have large bodies of material, such as mathematics, physical sciences, engineering applications, etc. However, we should realize that much of what is considered "factual" today may tomorrow be viewed from a different angle. We may refer to the displacement of classical by Quantum mechanics as an example, or to the concept of a round world as contrasted with the idea of a flat world.

In the second division, the "intangibles," we may also point out that a concept of mystical and imaginative character today may become a widely recognized "factual" item of tomorrow. The nature of electric current, radio waves, etc., may be cited as examples of this type of change in the past in the physical world.

We must thus realize that the line of demarkation between the two divisions is none too definite and steady. Nevertheless, we

often feel that a great difference in the basic nature of certain concepts exists, i.e., that a so-called "fact" is solid and that an "intangible" is always going to be elusive.

The second category of thought may contain, and usually does, many questions to which no definite answer can be given on the basis of present knowledge. Here we often find various groups offering what they seem to consider the correct answer in diametrical opposition to the answers of other groups. Of the numerous examples of this which occur on every hand in daily life, we may mention Christianity *vs.* Islam, pacifists *vs.* militarists, socialists *vs.* "rugged individualists," labor *vs.* capitalist, etc. What should the engineering educator do with these intangibles—if anything? Should the engineering educator turn his analytical gaze in this direction or is it a field outside his domain of proper activity—to which his work has no relation?

All of us are familiar with the excellent work which the S. P. E. E. has conducted in the last decade by way of investigating engineering education. This work was conceived and executed largely during the boom of the twenties. Its nature was determined accordingly. At the present time we are living under conditions which were not dreamed of when the questionnaires for the investigation were formulated. It is not surprising, therefore, that little if any attention was directed to questions which may be very important today. Thus, we find that the bible of engineering education may have to have a new testament added if engineering educators are to contribute constructive ideas in our present chaotic world.

From the results of the investigation of engineering education and from other well known facts, I believe we can safely conclude that in category No. 1 we were not found wanting. In the world of "concrete" facts the engineer has excelled and engineering education has produced with flying colors. It was largely, if not exclusively, in this field that we felt our duty to lie—as engineering educators, we produced graduates who were capable of dealing with the problems they encountered, of this nature. So capable were they, that in the industrial world there came to exist a condition of so called "overproduction."

It is at this point that we are forced as engineering educators to consider category No. 2—the world of "intangibles." We are faced with a situation without parallel in previous history. Our graduates leave our cloistered walls to seek a life's work in a "practical" world of paradoxes—if we choose to view the situations as such. The profession for which they are trained has created a new situation in the world of today. As point No. 1, I wish to state that as a minimum objective, we, as engineering educators, should attempt to clarify a philosophy of the engineers accom-

plishments and duties with respect to life as a whole. The instant we attempt to do this we come face to face with the "intangibles."

In the last several years I have been interested to determine the attitudes and outlooks of graduates, both old and young, as well as undergraduates of engineering colleges. I have been rather disappointed, as a rule, in their lack of a grasp of a sound philosophy of the present situation. It seems to me that they do not know exactly where the engineer stands in the picture. Some seem to think that he is to blame for the present deplorable conditions, some seem to have no hope in the future, and etc. It is this condition that we must correct. The best procedure in attacking this problem is yet to be determined. However, at Speed Scientific School we have started on planning a program. We realize that as time goes on it may be modified as experience seems to dictate. We are going to introduce a 3-hour course (1 quarter) in the senior year to deal with the intangibles. We intend to conduct this course in a fashion new to us.

A committee is now working on the preparation of this course. Its title may be "Technology and Civilization." It may be admitted that the committee has not (and may never) come to perfect agreement on many questions concerning this course. Item *a*, on which it does seem to agree is that the importance of the engineer in modern civilization should be emphasized. In my opinion, if this is to be done, we must enter into some detailed discussion of the intangibles—such as political, religious, historical, and sociological questions.

When we start into an inquiry of the profound effects of the engineer's work we find that on every hand it crosses or abuts or becomes confluent with these "intangible" fields.

Thus, we realize that the machinery, the vast available energy, and efficient methods produced by the engineer has reduced the amount of human labor required to produce the material used by mankind. This means that if consumption is not increased commensurately that each man must work a smaller number of hours. This simple fact and its ramifications are involved in our present situation of unemployment and the attendant multitude of questions pertaining to the sociological procedure best suited to cope with the situation. The constructive work of the engineer has created the possibility of extra leisure for the multitude—an edifying leisure I may say, which should definitely differentiate man from the slow horse which he has been in the past. However, he has given no unified thought to seeing how the product of his efforts should be handled to insure the finished product of a higher life for man.

At this point our paths cross those of the political, economic and sociological fields. However, the engineer is silent while the politician takes up the situation and begins to guide and interpret the effects the way he sees fit. The people of the country look to the politician for the answer—often not realizing that there is such a person as an engineer. The engineer himself, often digging himself a little deeper into a mental rut, does not realize that his profession is deeply involved. He does not realize his own importance in the matter.

These ideas and numerous similar ones are of daily occurrence. It is with this type of question that the course will be concerned.

In presenting the material it is obvious that the course should not degenerate into propaganda for any one individual's particular ideas concerning a question on some "intangible" which may be a very important question. On the contrary, the object should be to present the possible alternatives with as much fairness as possible and leave the student to draw his own conclusions. Thus in the field of politics, we should state as accurately as possible the ideas and objects of all parties and systems. We should also point to the methods used elsewhere in the world at present as well as in the past.

Above all, I feel that we should not start discussing a problem with promise No. 1 being that the present method is divine and immutable. I do not hesitate in a technical course to say that the radio set of tomorrow may be entirely different from the set of today. In the same way I do not see why we should not, in a discussion of politics, etc., point to certain other possibilities for human government and relations.

It has been repeatedly stated by some of my colleagues that our students do not have a proper background in the "intangible" fields—no more than a student of liberal arts has a proper background to consider engineering problems. I do not feel that this is entirely correct because our students have studied history (in high school), and economics, in addition to the operation of the physical world. Furthermore they have been living in the "nonfactual" second world all their lives. In any event they, as citizens, must vote, and have a right to consider the questions at hand in order to take an intelligent view on our country's affairs.

There is no doubt in my mind that many difficulties will be encountered in the handling of this course, but the main objectives will be achieved if we (1) give our students some idea of the true position of the engineer and his power and responsibility in modern civilization, and (2) to point to other fields of human thought with which they should be concerned and thus open other interest-

ing vistas for those who care to go further individually after graduation.

The world's affairs will be improved only by the thought and efforts of intelligent persons being directed to the questions of great importance. It is my feeling that the engineer has an excellent background of mental training and a knowledge of the facts which is not excelled by any other professional training. Therefore, in the course which this paper considers it is proposed that we do our small part in moving toward a happier and better human race.

Conclusions

Although the course we have in mind implies many questions and a great deal of work, I believe that it will help develop a more cheerful and earnest attitude on the part of the student who must face a world of paradoxes. It should help him to see the true value of the efforts and accomplishments of his profession and to realize that after all engineering is an important part of the broad plan of life. If it does this, it will supply a long felt need—it will be the finishing stroke of a true education.

There was a meeting of the **Maine Branch** of the Society for the Promotion of Engineering Education at Merrill Hall on April 12, 1935. Professor Weston S. Evans, of the Department of Civil Engineering, spoke on "Future Policies in Engineering Education." An interesting discussion followed.

Comprehensive examinations, similar in type to those given in 1934, will be given to seniors in the College of Technology, University of Maine, in May.

The results of these comprehensive examinations will be used

1. As a partial basis for determining graduation. In the computation of the final accumulative average, the average of eight semesters' work will carry a weight of four-fifths; and the average grade, received in the comprehensive examination, will carry a weight of one-fifth.
2. To determine departmental honors.
3. As a basis for recommendations for employment, whenever possible.

I. H. Prageman,
Secretary

The **Pacific Northwest Section** of the Society met for its third annual meeting on the Oregon State College campus on Friday and Saturday, April 5 and 6, 1935. Members from the University

At this point our paths cross those of the political, economic and sociological fields. However, the engineer is silent while the politician takes up the situation and begins to guide and interpret the effects the way he sees fit. The people of the country look to the politician for the answer—often not realizing that there is such a person as an engineer. The engineer himself, often digging himself a little deeper into a mental rut, does not realize that his profession is deeply involved. He does not realize his own importance in the matter.

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of Washington, Washington State College, University of Idaho, and Montana State College registered on Friday afternoon. In conjunction with the trip to the meeting, a group of the delegates scheduled an inspection trip to view the construction work at Bonneville Dam which is one unit of the Government's Columbia Basin PWA projects. They reported a very enjoyable as well as a profitable trip.

The first meeting was held Friday evening at 6:30 in the Memorial Union dining room. Sixty-five delegates and members of the Oregon State College faculty were present. R. H. Dearborn, Dean of the School of Engineering, Oregon State College, welcomed the delegates to the local campus. After a short intermission a business and technical meeting was held. Professor E. R. Wilcox, of the University of Washington, presented a paper on "A Review of Reports of the Engineers' Council for Professional Development." Professor Wilcox emphasized the value of accrediting engineering colleges, and the desirability of obtaining uniformity in degrees granted by engineering colleges. The report was discussed by Professor J. E. Buchanan of the University of Idaho and Professor S. H. Graf of Oregon State College.

At the business session, the University of Idaho extended an invitation to hold the fourth annual meeting at Moscow next spring. The invitation was accepted. The following officers were elected for the ensuing year:

Chairman—Professor R. H. Hull, U. of Idaho,
Vice-Chairman—Professor G. W. Holcomb, O.S.C.,
Secretary—Professor J. E. Buchanan, U. of Idaho.

Saturday morning from 9:00–11:00 A.M. the delegates were taken on an inspection tour of the engineering laboratories. Senior students in engineering accompanied the delegates through the buildings. The period from 11:00 to 12:00 A.M. was given over to personal conferences of the delegates with the local staff, in order that problems of individual interest could be discussed informally.

An informal luncheon was held in the Memorial Union at 12:15. Fifty-eight members attended the luncheon.

The Saturday afternoon session met at 2:00 P.M. in the auditorium of the Physics Building for the following program, with Vice-Chairman McMinn presiding:

"Social Implications of an Engineering Education," H. G. Tyler, U. of W.
Discussion, J. H. Johnson, U. of I.
"Mathematics to Meet Engineering Requirements," J. R. Griffith, O. S. C.

Discussion, W. D. Tallman, M. S. C.
"President Roosevelt's 'Science Advisory Committee Report' and its Relation to Engineering Education," R. H. Hull, U. of I.
Discussion, H. V. Carpenter, W. S. C., B. F. McMinn, U. of W.

The papers all provoked considerable discussion from the members, and general interest for each was in evidence.

The final meeting, with Dean R. H. Dearborn presiding, was held at the Hotel Benton. This was an informal dinner for members and ladies. A short entertainment was presented by students in music and dancing immediately following the dinner. President G. W. Peavy of Oregon State College addressed the group on the need for "Liberalizing the Engineering Curricula." He very emphatically pointed out the need for engineers adequately trained in the social and economic needs of the country in order that they may solve these problems in the future.

G. W. HOLCOMB,
Secretary

Purdue University.—Dr. John Layton Bray, Professor of Metallurgy, was appointed head of the School of Chemical Engineering to succeed Professor H. C. Peffer, who died last summer. Dr. Bray is a graduate of the Massachusetts Institute of Technology with the degree of Bachelor of Science in Mining and Metallurgical Engineering in 1912. In 1930 he received the Ph.D. degree in Metallurgy from M. I. T. From 1912 to 1922 Professor Bray was connected with mining and metallurgical industries of three different continents. Since 1923 he has held the position as Professor of Metallurgy at Purdue University. Professor Bray is author of books on metallurgy and ore dressing and holds patents on lead coating. He has also been responsible for several important research projects which have been carried on during recent years at Purdue University.

NEW MEMBERS

HOADLEY, GEORGE B., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. D. C. Jackson, C. E. Tucker.

MUSE, LEO J., Instructor in Civil Engineering, Louisiana State University, Baton Rouge, La. L. J. Lassalle, D. S. Anderson.

NEFF, THOS. W., Instructor in Machine Shop, Louisiana State University, Baton Rouge, La. L. J. Lassalle, D. S. Anderson.

RAHM, LOUIS F., Assistant Professor of Mechanical Engineering, Princeton University, Princeton, N. J. A. M. Greene, F. A. Heacock.

ROGERS, FRED A., Dean of Engineering, Professor of Electrical Engineering, Lewis Institute, Chicago, Ill. H. H. Higbie, J. Raleigh Nelson.

SIMON, GEORGE H., Assistant Professor of Mechanical Engineering, Louisiana State University, Baton Rouge, La. L. J. Lassalle, D. S. Anderson.

WOOLRICH, WILLIS R., Chief, Agricultural Industries Division, Tennessee Valley Authority, Fountain City P. O., Knoxville, Tenn. Chas. E. Ferris, E. L. Carpenter.

The following sections of this Society have been approved by Council:

Illinois-Indiana Section—organization meeting held at Purdue University, April 6, 1935.

Iowa-Wisconsin Section—organization meeting held at the University of Wisconsin, April 13, 1935.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Checking Student Drawings.—An ever-present problem of the drawing instructor is that of checking student drawings. He is anxious to correct every error and to make every possible suggestion for improving the correctness and appearance of the drawing. However, only a limited amount of time is available for checking each drawing and the instructor hesitates to write all over a drawing the student has worked on for some time.

The instructors in drawing at the University of Washington used a method this year for checking drawings which has proved highly successful. In the course in shop drawing the drawings were all made, in pencil or ink, so they could be blue-printed. Each student was assessed fifteen cents, which covered the bare cost of making one blue-print from each drawing during the entire course. This blue-print was stamped with a rubber stamp "For checking only," and all the corrections were made on the print instead of on the original, exactly as a checker would check a drawing in a drafting office. A red line was drawn through every note or figure on the sheet that was found to be correct. All errors were corrected with a yellow pencil. The student then made all indicated changes on his original drawing and returned it to his instructor for final checking and acceptance.

There are several marked advantages to this method:

1. The student sees how well his drawing will reproduce.
2. He learns a great deal from the many corrections and suggestions given.
3. He appreciates the pains the instructor takes in correcting it.
4. He tries harder because he knows it will be checked thoroughly.
5. He has the satisfaction of having a finished drawing which is correct enough to pass into a shop.
6. He becomes somewhat familiar with drafting-room procedure and feels that he has worked on a real job.

This method requires very little more of the instructor's time than the hit-or-miss method of correcting drawings by their appearance, and it certainly gives the instructor the satisfaction which can only come from the assurance of a teaching job that has been well done.

Contributed by FRANK M. WARNER, Associate Professor of Engineering Drawing, University of Washington.

BOOK REVIEWS

Structural Design in Steel. SHEDD. Wiley and Sons.

One of the most difficult problems of the teacher of structural design is the development of the attitude of the student to the point where he considers the design problem as a whole, and visualizes the functional relations existing between portions and individual members of a structural frame. Professor Shedd develops this point in the beginning and his resulting analysis of structural frames into their fundamental forms starts the student on the right path with a clear picture of the purposes of design. New problems that are up to date, accompanied by up-to-date specifications and with the author's presentation of the subject, combine to form a concise introduction to design. Teachers will appreciate the complete sets of design calculation sheets which will serve as examples, to their students, of "How design calculations should be presented." The author is to be complimented on the quality and selection of the numerous illustrations of this text.

Introduction to Electric Transients. KURTZ AND CORCORAN. Published by John Wiley & Sons. 331 pages.

This book is divided into two sections, Direct Current Transients and Alternating Current Transients. It also contains in addition an appendix which treats differential equations of circuit theory, Heaviside's operational calculus, Graeffe method of solving algebraic equations, and exponential functions.

Quoting from the authors' Preface, we find:

"The method of presentation employed is to consider each type of transient under three distinct headings, namely

1. Physical considerations.
2. Mathematical Analysis.
3. Oscillograph Verification."

This method of presentation is followed throughout the book. The mathematical analysis consists of deriving the equations both by conventional mathematics and solutions using Heavisides operational calculus. The analysis is so presented that one or both solutions may be used without interfering with the continuity of study. After the physical and mathematical aspects have been given consideration, oscillographic records of current and power are shown which verify the study. Anyone who has taken oscil-

lograph records will appreciate those found in this book. They form the most complete collection of records of this type that the reviewer has found in any book.

The study includes the R, L, C, RC, RL, and RLC circuits both in series and parallel and also under particular boundary conditions. Considerable space is given to inductively coupled circuits. Variable R, L, and C is also given considerable attention. At the end of each chapter will be found problems bringing out the principles that the chapter discusses.

The reviewer believes that this book is suited for any individual or group interested in this phase of electrical study. It is a worthwhile contribution to this field.

J. A. W.

French's Engineering Drawing, 5th Edition. THOMAS E. FRENCH, Professor of Engineering Drawing, The Ohio State University. McGraw Hill Book Co., Inc., 1935. 481 pages.

French's new edition of his well-known Engineering Drawing text shows that good books can still be improved. Professor French has changed the order of chapters in this new revised edition so that now the chapters follow in their correct order through Orthographic projection, Sections and Conventions, Dimensions and Notes, Bolts screws etc., Working Drawings, Technical Sketching, then on to Developments, Pictorial Representation, and to the other chapters contained in previous editions.

It is noted in this new edition that quite a few problems on aeroplanes have been introduced. Differing from previous editions the problems are stated below the figure referred to instead of being placed in a group immediately preceeding or following the figures as in older editions. Students should not have any trouble with this new system of problem assignments. In regard to problems there are over 150 new problems, and nearly 100 new illustrations, the cuts being larger and more legible. Both the illustrations and text conform to the new standards recently adopted by the American Standards Association.

This new edition will be much more convenient to use both in laboratory and in recitation classes.

W. IRWIN SHORT

Highway Design and Construction. ARTHUR G. BRUCE, Senior Highway Engineer, United States Bureau of Public Roads. $6 \times 8\frac{1}{2}$. 628 pages; illustrations and tables. International Textbook Company. $4.00.

Both the arrangement and contents of this text are entirely new and the material is drawn from current highway engineering prac-

tice rather than from an analysis of existing college courses. The book further has the merit of not being a mere revision of an older work. The author explains that the text has had the benefit of the criticism of several professors of highway engineering in different parts of the United States, and the final editing of Professor Ben H. Petty of Purdue University. His final comment that the criticism left the arrangement originally developed by the author essentially unchanged is understandable when it is known that this arrangement starts off with a chapter on highway administration and proceeds through chapters on location, design, grading, drainage, soil studies, low cost roads, sub-grade treatments, etc., to chapters on the various types of road surfacing, followed by chapters on sidewalk curbs and gutters, guard rails, sign posts, etc., highway beautification and lighting, street cleaning and snow removal, comparison of various surfaces, estimates, contracts, specifications, etc. A chapter on the testing of highway materials is also included.

Each chapter is followed by a bibliography of more recent highway articles. In fact one's attention is especially attracted by the up-to-date character of all the information contained in the book and by the comprehensive treatment of fundamental principals rather than in extremely detailed standardized instruction such as is likely to be found in instruction manuals issued by various highway departments and varying in their detail from state to state. And yet a surprisingly large amount of fundamental material is included due to the concise and direct nature of the presentation.

The book impresses one as excellent for use as a college text book and because of the very evident use of the most recent sources of information, many highway officials and engineers are likely to find its perusal profitable.

L. W. McIntyre

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TUFTS COLLEGE, Tufts College, Mass., John Albert Cousens, President, *Geo. P. Bacon, Dean* 1914

UNIVERSITY OF UTAH, Salt Lake City, Utah, George Thomas, President, *R. B. Ketchum, Dean* 1914

VANDERBILT UNIVERSITY, Nashville, Tenn., J. H. Kirkland, Chancellor, *F. J. Lewis, Dean* 1914

UNIVERSITY OF VERMONT, Burlington, Vt., Guy W. Bailey, President, *G. F. Eckhardt, Dean* 1915

VILLANOVA COLLEGE, Villanova, Pa., E. V. Stanford, President, *C. T. Humphrey, Dean* 1921

VIRGINIA POLYTECHNIC INSTITUTE, Blacksburg, Va., Julian A. Burruss, President, *E. B. Norris, Dean* 1924

UNIVERSITY OF VIRGINIA, University, Va., J. L. Newcomb, President, *W. S. Rodman, Dean* 1915

UNIVERSITY OF WASHINGTON, Seattle, Wash., Lee Paul Sieg, President, *R. G. Tyler, Dean* 1934

WASHINGTON UNIVERSITY, St. Louis, Mo., George R. Throop, Chancellor, *A. S. Langsdorf, Dean* 1914

WASHINGTON AND LEE UNIVERSITY, Lexington, Va., Francis P. Gaines, President, *James L. Howe, Dean* 1924

STATE COLLEGE OF WASHINGTON, Pullman, Wash., E. O. Holland, President, *H. V. Carpenter, Dean* 1924

WESTINGHOUSE TECHNICAL NIGHT SCHOOL, East Pittsburgh, Pa., R. A. McPherson, Manager 1924

UNIVERSITY OF WISCONSIN, Madison, Wis., Glenn Frank, President, *F. E. Turneaure, Dean* 1914
WORCESTER POLYTECHNIC INSTITUTE, Worcester, Mass., Ralph Earle, President 1913
UNIVERSITY OF WYOMING, Laramie, Wyo., A. G. Crane, President. 1925
YALE SCHOOL OF ENGINEERING, Yale University, New Haven, Conn., James R. Angell, President, *E. E. Doherty, Dean* 1917

Total Institutional Members 121

ADDITIONS AND CORRECTIONS TO LIST OF INDIVIDUAL MEMBERS IN 1934 YEAR BOOK.

ADENDORFF, JOHN, Professor of Industrial Engineering, University of Akron, Akron, Ohio 1934

AMADOR, FRANK J., Assistant Instructor in Electrical Engineering, University of Kansas, Lawrence, Kansas 1935

ANDERSON, EDWARD, Associate Professor of Mechanical Engineering, State University of Iowa, Iowa City, Iowa. 1928

ANDERSON, H. W., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Iowa. 1925

ANDERSON, PAUL, Instructor in Structural Engineering, University of Minnesota, Minneapolis, Minn. 1934

ANDREWS, STEPHEN C., Instructor in Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1934

ARM, DANIEL L., Assistant Professor of Mechanical Engineering, Lafayette College, Easton, Pa. 1934

AYRES, EDMUND D., Assistant Professor of Electrical, Steam and Gas Engineering, University of Wisconsin, Madison, Wis. 1934

BABCOCK, JOHN B., Professor of Railway Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1923

BAILEY, NEIL P., Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1930

BAIRD, RALPH W., Tyler, Texas 1926

BAKER, EDWARD G., Instructor in Mathematics, Newark College of Engineering, Newark, N. J. 1934

BARNES, F. A., Professor of Railroad Engineering, Cornell University, Ithaca, N. Y. 1904

BATCHELDER, DEAN E., 701 Elmira Street, Pasadena, Calif. 1930

BEAL, GEORGE M., Associate Professor of Architecture, University of Kansas, Lawrence, Kansas 1935

BELZ, CHARLES J., Assistant Professor of Civil Engineering, University of Dayton, Dayton, Ohio 1929

BENNETT, CLAUDIUS E., Engineer, National Power Survey, Federal Power Commission, Washington, D. C. 1931

BERGGREN, WILLARD P., Technical Assistant in Mechanical Engineering, University of California, Berkeley, Calif. 1934

BIBB, SAMUEL F., Assistant Professor of Mathematics, Armour Institute of Technology, Chicago, Ill. 1935

BINGHAM, EUGENE C., Professor of Chemistry, Lafayette College, Easton, Pa. 1934

BJORNDAL, MAGNUS, Chief Engineer, The Daven Company, 807 Summit Street, Jersey City, N. J. 1934

BLACK, HAYSE H., State Technician, 313 South Park Avenue, Springfield, Ill. 1929

BLOXSOME, JOHN L., Assistant Professor of English, Rose Polytechnic Institute, Terre Haute, Ind. 1934

BOARDMAN, HAROLD S., President Emeritus, University of Maine, 172 Main Street, Orono, Me. (*President, 1930–31; Vice-President, 1923–4; Member of Council, 1919–24, 1930–*) 1903

BOYCE, EARNEST, Professor of Civil Engineering, University of Kansas, Lawrence, Kansas. 1924

BRACKETT, ELMER E., Professor of Agricultural Engineering, University of Nebraska, Lincoln, Nebr. 1920

BRECKENRIDGE, ROBERT W., Instructor in Mechanical Engineering, Iowa State College, Ames, Iowa. 1934

BREED, CHARLES B., Professor and Head, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1904

BRELAND, JAMES E., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas. 1934

BRENTON, WALTER, Chief Engineer, Portland General Electric Company, 922 Electric Building, Portland, Ore. 1934

BRIGGS, GARLAND, Director of Education, International Business Machine Company, 108 Stockton Street, Princeton, N. J. 1934

BULLEN, CHARLES V., Professor and Head, Department of Electrical Engineering, Texas Technological College, Lubbock, Texas. 1934

BURINGTON, RICHARD S., Assistant Professor of Mathematics, Case School of Applied Science, Cleveland, Ohio. 1934

BURR, WM. H., Emeritus Professor of Civil Engineering, Columbia University, Consulting Engineer, New Caanan, Conn. 1893

BURRIS-MEYER, HAROLD, Assistant Professor of Humanities, Stevens Institute of Technology, Hoboken, N. J. 1934

BUSH-BROWN, HAROLD, Professor of Architectural Engineering, Georgia School of Technology, Atlanta, Ga. 1934

BUTTS, ALLISON, Associate Professor of Metallurgy, Lehigh University, Bethlehem, Pa. 1934

CAMPBELL, JOSEPH W., Assistant Professor of Metallurgy, Purdue University, Lafayette, Ind. 1934

CARMICHAEL, COLIN, Assistant Professor of Mechanical Engineering, University of North Carolina, Chapel Hill, N. C. 1934

CARPENTER, JAY A., Professor of Mining, University of Nevada, Reno, Nev. 1934

CARSON, GORDON B., Instructor in Mechanical Engineering, Case School of Applied Science, Cleveland, Ohio. 1934

CARVIN, FRANK D., Assistant Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. 1925

CHAPIN, LLOYD W., Associate Professor of English, Georgia School of Technology, Atlanta, Ga. 1934

CHILD, ALFRED T., Associate Professor of Chemical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1934

CHILDS, WILL P., Mechanical Engineer, 824 Arch Street, Ann Arbor, Mich. 1931

CHINN, HARVE N., Instructor in Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1934

CLAPP, M. ROGER, Instructor in Mechanical Engineering, Texas Technological College, Lubbock, Texas. 1934

COMPTON, HORACE B., Assistant Professor of Rational and Technical Mechanics, Rensselaer Polytechnic Institute, Troy, N. Y. 1934

COPLEY, JOHN O., Special Teacher, 25 Sylvan Place, New Rochelle, N. Y. 1926

CRABTREE, FREDERICK H., Instructor in Civil Engineering, Tufts College, Tufts College, Mass. 1934

CREAMER, WALTER J., Associate Professor of Electrical Engineering, University of Maine, Orono, Me. 1922

CREDLE, ALEXANDER B., Assistant Professor of Electrical Engineering, Clemson College, Clemson College, S. C. 1935

CREESE, JAMES, Vice President and Treasurer, Stevens Institute of Technology, Hoboken, N. J. 1934

CRENSHAW, JOHN B., Professor and Head, Department of Modern Languages, Georgia School of Technology, Atlanta, Ga. 1934

CREWS, L. R., Captain of Military Science and Tactics, Kansas State College, Manhattan, Kansas. 1934

CROCKETT, CHAS. W., Emeritus Professor of Mathematics and Astronomy, Rensselaer Polytechnic Institute, 221 Stow Avenue, Troy, N. Y. 1912

CUDWORTH, JAMES R., Director, School of Mines, Professor of Mining, University of Alabama, University, Ala. 1934

DAASCH, HARRY L., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1934

DANIEL, CHARLES M., 9343 Burton Way, Beverley Hills, Calif. ... 1926

DAVIDSON, ARTHUR J., Instructor in Civil Engineering, University of Idaho, Moscow, Ida. 1934

DEARBORN, R. H., Acting Dean, Professor of Electrical Engineering, Oregon Agricultural College, Corvallis, Ore. 1917

DENNY, GEORGE H., President, University of Alabama, University, Ala. 1934

DISTLER, THEODORE, A., Dean of the College, Lafayette College, Easton, Pa. 1928

DOUGLAS, JOHN A., 313 McDonald Avenue, Mobile, Ala. 1930

DOWNING, DONALD G., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934

DOWNING, LEWIS K., Dean, School of Engineering and Architecture, Howard University, Washington, D. C. 1929

DOWS, HAROLD W., Assistant Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934

DUCKERING, W. E., Professor and Head, Department of Civil Engineering and Mathematics, Alaska Agricultural College and School of Mines, College, Alaska. 1917

DUDLEY, W. M., Instructor in Mechanics, Case School of Applied Science, Cleveland, Ohio. 1934

DUNHAM, CLARENCE W., Assistant Engineer, Design Division, Port of New York Authority, New York City. 1934
DUNLAP, ARCHIBALD L., Associate Professor of Mechanical Engineering, Tulane University, New Orleans, La. 1934
DUTTON, HENRY P., Professor and Acting Chairman, Department of Social Science, Armour Institute of Technology, Chicago, Ill. 1935
EARLE, CHESTER R., 5714 Blackstone Avenue, Hyde Park Sta., Chicago, Ill. 1922
ELLIS, CHARLES A., Professor of Structural Engineering, Purdue University, Lafayette, Ind. 1934
ELLIS, JAMES L., Associate Professor of Electrical Engineering, Georgia School of Technology, Atlanta, Ga. 1935
ENDSLEY, L. E., Lecturer in Mechanical Engineering, University of Pittsburgh, 516 East End Avenue, Pittsburgh, Pa. 1907
ENGER, M. L., Dean, College of Engineering, Director of Engineering Experiment Station, University of Illinois, Urbana, Ill. (*Member of Council, 1921–4*) 1907
FAIRFIELD, HOWARD P., Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934
FAITH, LAWRENCE, Assistant Professor of Industrial Chemistry, Kansas State College, Manhattan, Kansas. 1934
FARABEE, RAY L., Associate Professor of Metallurgy, University of Alabama, University, Ala. 1934
FASSETT, FREDERICK G., JR., Assistant Professor of English and History, Massachusetts Institute of Technology, Cambridge, Mass. 1935
FAY, ALBERT H., Assistant Professor of Mining Engineering, Lafayette College, Easton, Pa. 1934
FISHER, ROBERT A., Instructor in Chemical Engineering, University of Louisville, Louisville, Ky. 1934
FITHIAN, JAMES H., Associate Professor of Mathematics, Kansas State College, Manhattan, Kansas. 1934
FLETCHER, WENDELL S., Instructor in Engineering, Fullerton District Junior College, Fullerton, Calif. 1934
FLODIN, JOHN, 404 Vanderbilt Avenue, Brooklyn, N. Y. 1924
FOSTER, E. S., Electrical Engineer, Electric Controller & Mfg. Co., Cleveland; 378 Elm Road, N.E., Warren, Ohio. 1911
FOWLER, RUSSELL W., Assistant Professor of Drawing, University of Wisconsin, Madison, Wis. 1934
FRECKER, G. ALAIN, Lecturer in Engineering, Memorial University College, St. Johns, Newfoundland. 1934
FREIRE, V. DA SILVA, Professor of Technique of Materials, Dean, Polytechnic School of State, P. O. Box 18, Sao Paulo, Brazil. 1929
FREUD, B. B., Professor of Chemistry, Armour Institute of Technology, Chicago, Ill. 1934
GARRAN, FRANK W., Professor of Civil Engineering, Dean, Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H. 1925

GOODRICH, RALPH D., Professor of Civil Engineering, Dean, School of Engineering, University of Wyoming, Laramie, Wyo. 1929
GRANDY, LEWIS S., 319 A, Bureau of Reclamation, Customs House, Denver, Colo. 1927
GROAT, B. F., Consulting Engineer, 20 Chapel Street, Brookline, Mass. 1889
GUMMERE, H. V., Haverford College, Haverford, Pa. 1914
GWIAZDOWSKI, ALEXANDER P., Associate Professor of Machine Production, Case School of Applied Science, Cleveland, Ohio. 1928
GWINN, IRA J., Assistant Professor of Physics and Pre-Engineering, Morningside College, Sioux City, Iowa 1934
HALLIGAN, CLAIR W., Engineer, American Telephone and Telegraph Co., 463 West Street, New York City. 1925
HAMDI, A. F., 721 W. Beaver Street, State College, Pa. 1932
HARTSHORN, WILFRED W., Instructor in Mathematics, Brawley Union High School and Junior College, Brawley, Calif. 1934
HATHAWAY, ARTHUR S., Assistant Professor of Surveying and Drawing, Northwestern University, Evanston, Ill. 1934
HELANDER, LINN, Professor and Head, Department of Mechanical Engineering, Kansas State College, Manhattan, Kansas. ... 1935
HEMPSTEAD, JEAN C., Assistant Professor of General Engineering, Iowa State College, Ames, Iowa 1935
HEROD, NEWTON S., Professor of Physics, Georgia School of Technology, Atlanta, Ga. 1934
HILL, ARTHUR M., Assistant Professor of Mechanical Engineering, Tulane University, New Orleans, La. 1931
HOLLISTER, S. C., Director, School of Civil Engineering, Cornell University, Ithaca, N. Y. 1916
HOUSER, SHALER C., Professor of Engineering, University of Alabama, University, Ala. 1934
HOUSE, E. B., Professor of Civil and Irrigation Engineering, Dean, School of Engineering, Colorado State Agricultural College, Ft. Collins, Colo. 1913
HOWE, JOSEPH W., Assistant Professor of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa. 1934
HUTCHISON, ALBERT W., JR., Instructor in Civil Engineering, Vanderbilt University, Nashville, Tenn. 1934
JENSEN, GORDON L., c/o Tennessee Valley Authority, Knoxville, Tenn. 1929
JONES, LYNN W., Assistant Professor of Physics and Engineering, University of Redlands, Redlands, Calif. 1934
KEATON, L. D., Assistant Professor of Industrial Education, East Texas State Teachers College, Commerce, Texas 1934
KELLOGG, JOSEPH M., Professor and Head, Department of Architecture, University of Kansas, Lawrence, Kansas 1935
KENNY, FREDERIC J., Professor of Engineering, Manhattan College, New York City. 1934
KENRICK, GLEASON W., Professor of Physics, University of Porto Rico, Rio Piedras, P. R. 1927
KIELY, EDMOND R., Professor of Engineering, St. Mary's College, Halifax, N. S. 1934

KING, JOHN A., Professor of Mechanical and Industrial Engineering, University of Kansas, Lawrence, Kansas 1935
KINNEY, EDWARD D., Associate Professor of Chemical Engineering, University of Kansas, Lawrence, Kansas. 1934
KINTNER, ROBERT C., Assistant Professor of Chemical Engineering, Bucknell University, Lewisburg, Pa. 1934
KISSAM, PHILIP, Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J. 1934
KOCH, RUTH L., Secretary, School of Music, University of Louisville, Louisville, Ky. 1927
KOPAS, JOSEPH S., Instructor in Electrical Engineering, Fenn College, Cleveland, Ohio 1934
KROTZER, F. W., 2210 E. Greenwich Avenue, Milwaukee, Wis. ... 1929
KRYNINE, D. P., Research Associate in Soil Mechanics, Yale University, New Haven, Conn. 1934
KULP, MARK R., Assistant Professor of Agricultural Engineering, Irrigationist, Agricultural Experiment Station, University of Idaho, Moscow, Ida. 1934
KURTZ, JOHN W., Head, Pre-Engineering Department, Municipal University of Omaha, Omaha, Nebr. 1934
LADNER, A. COLLINS, Assistant Professor of Mathematics and Engineering Science, Denison University, Granville, Ohio 1934
LANG, FRED A., Professor of Highway Engineering, University of Minnesota, Minneapolis, Minn. 1934
LANING, WILLARD A., Instructor in Electrical Engineering, Gettysburg College, Gettysburg, Pa. 1930
LASSALLE, LEO J., Professor of Engineering Mechanics, Dean, College of Engineering, Louisiana State University, Baton Rouge, La. 1934
LAUBACH, MERIT L., Head, Industrial Arts, State Teachers College, Terre Haute, Ind. 1934
LEISTER, JOHN S., Assistant Professor of Civil Engineering, University of Alabama, University, Ala. 1934
LEUTWILER, O. A., Professor and Head, Department of Mechanical Engineering, University of Illinois, Urbana, Ill. (*Member of Council, 1918–21*) 1906
LINDSAY, FRANK B., Dean of Men, San Bernardino Valley Junior College, San Bernardino, Calif. 1928
LOCKE, WILLIAM W. J., Instructor in Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934
LOCKWOOD, H. J., 127 State House, Concord, N. H. 1929
LUDDEN, DWIGHT, J., Instructor in Drafting, Community High School, Granite City, Ill. 1933
LYSE, INGE, Research Associate Professor of Engineering Materials, Lehigh University, Bethlehem, Pa. 1934
MACLEAN, JOHN A., Instructor in Mechanical Engineering, University of North Carolina, Chapel Hill, N. Car. 1934
MALCOLM, W. L., Professor of Municipal Engineering, Queens University, Kingston, Ont., Canada. 1934
MANN, EDWIN W., Instructor in Chemistry, Rose Polytechnic Institute, Terre Haute, Ind. 1934

MAO, T. E., Director, Chien Tang River Bridge Office, Zakow, Hangchow, China 1923
MARSDEN, RAYMOND R., Hanover, N. H. 1922
MASON, H. LEA, Taylor Instrument Companies, Rochester, N. Y. 1925
MAURER, EDWARD R., Professor of Mechanics, University of Wisconsin, Madison. Wis. (*Vice-President, 1918–9; Member of Council, 1901–12.*) **Seventh Recipient Lamme Medal (1934)** 1897
MAXWELL, FRED R. JR., Associate Professor of Electrical Engineering, University of Alabama, University, Ala. 1934
MAXWELL, MAXWELL C., General Supt., Yale & Towne Mfg. Co., Stamford, Conn. 1934
MCCOMBS, GLENN C., Instructor in Mechanical Drawing, Carnegie Institute of Technology, Pittsburgh, Pa. 1934
MCCUAIG, DONALD H., Instructor in Mechanical Engineering, University of Alabama, University, Ala. 1934
MCCULLOUGH, ERWIN W., 3924 No. New Jersey Street, Indianapolis, Ind. 1931
MCKEE, EDD R., Professor and Head, Department of Electrical Engineering, University of Vermont, Burlington, Vt. 1934
MCNEELY, JOHN K., 218 No. St. Andrews Place, Los Angeles, Calif. 1926
MCNOWN, WILLIAM C., Professor and Head, Department of Civil Engineering, University of Kansas, Lawrence, Kansas 1935
MEEKER, W. H., Professor Emeritus, Mechanical Engineering, Iowa State College, Ames, Iowa. 1903
MEIGS, HOWARD H., Instructor in Drawing, University of Alabama, University, Ala. 1934
MILLER, F. CLIFFORD, Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. 1934
MILLER, HARRY, Instructor in Agricultural Engineering, University of Idaho, Moscow, Ida. 1934
MILLS, G. H., Instructor in Electrical Engineering, Case School of Applied Science, Cleveland, Ohio. 1934
MILTON, HUGH M., JR., Acting Dean, Engineering School, New Mexico State College, State College, N. Mex. 1934
MIRABELLI, EUGENE, Assistant Professor of Structural Design, Massachusetts Institute of Technology, Cambridge, Mass. .. 1934
MOENCH, HERMAN A., Instructor in Electrical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1934
MOORE, H. W., Instructor in Vocational Education, University of Alabama, University, Ala. 1935
MOORMAN, ROBERT B. B., Assistant Professor of Civil Engineering, University of Mississippi, Oxford, Miss. 1933
MORGAN, CHARLES L., Associate Professor of Architecture, Kansas State College, Manhattan, Kansas. 1934
MUNSON, THURMOND A., Professor of Hydraulic Engineering, A. & M. College of Texas, College Station, Texas. 1934
NARMORE, PHIL B., Assistant Professor of Engineering Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. 1934
NEUS, ENGELBERT, Professor of Drafting, College of the City of New York, New York City. 1934

NEWING, RALPH L., Manager, Educational Department, International Textbook Co., Scranton, Pa. 1934
NORTHRUP, RALPH T., Assistant Professor of Engineering Drawing, Wayne University, Detroit, Mich. 1934
O'DONNELL, RAYMOND, Professor of Hydraulics and Sanitary Engineering, The Pennsylvania State College, State College, Pa. .. 1934
OEHRLI, JOHN W., 40 Edgemont Road, Asheville, N. C. 1931
OSBORN, FRANCIS C., Head, Industrial Arts Department, Arizona State Teachers College, Flagstaff, Ariz. 1934
OSBORNE, L. A., President, Westinghouse Electric International Co., 30 Rockefeller Plaza, New York, N. Y. 1911
OTTER, JOHN V., 912 Deakin Ave., Moscow, Idaho 1929
OWENS, THURSTON D., Assistant Professor of Electrical Engineering, Case School of Applied Science, Cleveland, Ohio. 1934
PAJOT, CLAYTON J., University of Detroit, Detroit, Mich. 1932
PARKS, RUSSELL B., Assistant Professor of English, Lewis Institute, Chicago, Ill. 1934
PATTEN, W. E., Civil Engineer, 1313 Shepherd St., South Boston, Va. 1915
PATTISON, FLOYD, Professor of Mechanical Engineering, Kansas State College, Manhattan, Kansas. 1934
PAXTON, CHARLES H., Associate in Mechanic Arts, University of California at Los Angeles, Calif. 1934
PERKINS, DONALD L., Assistant Professor and Head, Dept. of Mechanical Engineering, College of City of Detroit, Detroit, Mich. 1930
PERKINS, HAROLD C., Assistant Professor of Mechanical Engineering, Cornell University, Ithaca, N. Y. 1934
PHELPS, R. THAYER, Instructor in Chemistry, Colorado School of Mines, Golden, Colo. 1934
PORTER, R. CLAY, Instructor in Mechanical Engineering, University of Kentucky, Lexington, Ky. 1935
PROSSER, EDWARD T., Assistant Professor of Physics, Georgia School of Technology, Atlanta, Ga. 1934
QUINLAN, ROBERT E., 84 Galen Street, Waltham, Mass. 1931
RAW, RUTH M., Assistant Professor of English, University of Akron, Akron, Ohio 1935
REICH, HERBERT J., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1934
REYNOLDS, KENNETH C., Assistant Professor of Hydraulics, Massachusetts Institute of Technology, Cambridge, Mass. 1934
RHOADS, ROBERT L., Elk Club, Grass Valley, Calif. 1925
ROBB, ROBERT E., Antioch College, Yellow Springs, Ohio. 1927
SAGEN, GEORGE O., Instructor in Physics, Bakersfield Junior College, Bakersfield, Calif. 1934
SASHOFF, STEPHAN P., Assistant Professor of Electrical Engineering, University of Florida, Gainesville, Fla. 1934
SCHNEIDER, VALERIE, Associate Professor of Chemical Engineering, Texas Technological College, Lubbock, Texas 1935
SCHODER, ERNEST W., Professor of Experimental Hydraulics, Cornell University, Ithaca, N. Y. 1934

SCHOWALTER, C. H., Instructor in Mechanical Engineering, University of Idaho, Moscow, Ida. 1934

SEELY, F. B., Professor and Head, Department of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1913

SEEGRIST, WALTER H., Assistant Professor of Mechanical Engineering, Armour Institute of Technology, Chicago, Ill. 1934

SETTE, FRANCIS J., Associate Professor of Sanitary Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1925

SEVERNS, WILLIAM H., Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1934

SHEPARD, GEORGE H., Professor of Industrial Engineering and Management, Purdue University, Lafayette, Ind. 1934

SHULTZ, E. O., Instructor in Drawing, University of Minnesota, Minneapolis, Minn. 1934

SIEGFRIED, VICTOR, Instructor in Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934

SMITH, JAMES O., Instructor in Mechanics, University of Alabama, University, Ala. 1934

SMITH, LINUS B., Professor and Chairman, Department of Architecture, University of Nebraska, Lincoln, Nebr. 1934

SPEARS, SHOLTO M., Assistant Professor of Civil Engineering, Armour Institute of Technology, Chicago, Ill. 1935

SQUIRE, WALTER, Lecturer in Music Humanities, Stevens Institute of Technology, Hoboken, N. J., 962 Park Ave., New York City. 1934

ST. CLAIR, OSCAR A., Professor and Head, Department of Industrial Engineering, Engineering Drawing and Industrial Education, Texas Technological College, Lubbock, Texas. 1934

STAPLES, ARTHUR J., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934

STEVENS, HOWARD E., Assistant Professor of Machine Design, Rensselaer Polytechnic Institute, Troy, N. Y. 1934

SUBLET, FRANK G., Lecturer in Electrical Engineering Design, University of Melbourne, Kew, Melbourne E5, Australia. ... 1934

SWEENEY, ORLAND R., Professor and Head, Department of Chemical Engineering, Iowa State College, Ames, Iowa. 1934

SWINEFORD, CHARLES R., Associate Professor of Mechanical Engineering, Armour Institute of Technology, Chicago, Ill. 1935

SWITZER, FREDERICK G., Professor of Hydraulic Engineering, Cornell University, Ithaca, N. Y. 1934

TABER, THERON S., Instructor in Civil Engineering, Bakersfield Junior College, Bakersfield, Calif. 1934

TALBOT, ARTHUR N., Professor of Municipal and Sanitary Engineering, Emeritus, University of Illinois, Urbana, Ill. (*President, 1910–11; Vice President, 1909–10; Treasurer, 1902–04; Member of Council, 1902–.*) **Fifth Recipient Lamme Medal (1932)** 1893

TARPLEY, HAROLD I., Associate Professor of Electrical Engineering, The Pennsylvania State College, State College, Pa. 1934

TAPY, RALPH W., Instructor in Electrical Engineering, University of Detroit, Detroit, Mich. 1934

TATNALL, FRANCIS G., Manager, Testing Equipment Division, Baldwin-Southwark Corp., Philadelphia, Pa. 1935
THATCHER, ROMEYN Y., Assistant Professor of Civil Engineering, Cornell University, Ithaca, N. Y. 1934
THOMAS, MELVIN A., Professor and Head, Department of Electrical Engineering, New Mexico College of A. & M., State College, N. Mex. 1934
THOMPSON, MILTON J., Assistant Professor of Aeronautical Engineering, University of Michigan, Ann Arbor, Mich. 1934
TILGHMAN, HARRISON, Councillor-at-Law, 56 Pine Street, New York City. 1919
TUCKER, LEROY, Assistant Professor of Mechanics, The Ohio State University, Columbus, Ohio. 1927
TURNER, D. L., 805 Colonial Avenue, Norfolk, Va. 1898
TYRRELL, CECIL C., Instructor in Mechanical Engineering, University of Maine, Orono, Me. 1934
UICKER, JOHN J., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. 1933
VAN GAASBEEK, RICHARD M., Head, Department of Woodworking, Pratt Institute, 9524 127th St., Richmond Hills, N. Y. 1926
VETTER, HARRY F., 8735 162nd Street, Jamaica, N. Y. 1932
VOTH, JOHN J., Assistant Professor of Industrial Arts, Bethel College, Bethel College, Kansas. 1934
WALKER, AMASA, Manager of Educational Dept., Longmans, Green & Co., 114 Fifth Ave., New York City. 1914
WARD, GERALD C., 1311 Chandler St., Madison, Wis. 1929
WATSON, JOHN W., Professor of Inorganic Chemistry, Head, Department of Chemistry and Chemical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1934
WEBER, ERNST, Research Professor of Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1934
WEISSMAN, HAROLD E., Associate Professor of Mechanics and Structural Engineering, State University of Iowa, Iowa City, Iowa. 1934
WESTON, ARTHUR J., Chairman, Humanities, and Professor of English, Stevens Institute of Technology, Hoboken, N. J. .. 1934
WILBUR, JOHN B., Assistant Professor of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1934
WILCOX, GUY M., 5225 Ingleside Avenue, Chicago, Ill. 1926
WILCOX, JAMES E., Instructor in Engineering, Santa Rosa Junior College, Santa Rosa, Calif. 1934
WILLARD, ARTHUR C., President, University of Illinois, Urbana, Ill. 1922
WILSON, GEORGE W., Vice President, International Correspondence Schools, Scranton, Pa. 1935
WINN, C. C., Dean, College of Engineering, Detroit Institute of Technology, Detroit, Mich. 1934
WOODROW, JAY W., Professor and Head, Department of Physics, Iowa State College, Ames, Iowa. 1934
WRAY, ROBERT C., Instructor in Civil Engineering, University of Arkansas, Fayetteville, Ark. 1934
ZERBAN, A. H., Instructor in Mechanical Engineering, The Pennsylvania State College, State College, Pa. 1932
ZSCHOKKE, ARTHUR J., Modesto Junior College, Modesto, Calif. .. 1932

REMOVED FROM LIST OF MEMBERS IN 1934 YEAR BOOK.

Allen, L. N.
Anderson, Robert M.
Archibald, Leon

Bailey, Charles F.
Bangratz, Ernest G.
Bentley, Walter J.
Boothroyd, S. L.
Brahtz, J. H. A.
Brenke, W. C.
Brill, Philip B.
Brown, Wilson F.
Bullock, W. E.
Butler, Hartman L.

*Calderwood, Jas. P.
Cass, Riley T.
Cheatham, James C.
Chittenden, H. M.
Comstock, E. H.
Crouch, C. H.
Curfman, Lawrence E.

Danstedt, R. T.
Decker, A. J.
*Dickinson, Leonard P.
Doland, James J.

Fairbanks, Oscar W.
Finch, J. W.
Fordemwalt, F.
Frampton, George O.
Frankland, Edwin

Garst, Harvey O.
Graham, E. C.
Graham, Wm. P.
Graton, Louis C.
Grumman, H. R.
Guerin, Frederick J.

Hackley, R. A.
Hall, W. C.
Hammond, Robert J.
Harrington, T. H.
*Hatfield, Harold D.
Hazard, Clifton T.
*Herr, E. M.
Hewitt, C. E.
*Hill, J. E.
Hirota, Seiiti
Hitchcock, L. B.
Hobbs, Allan W.
Hoglund, Gustav O.
Holmes, William M.
*Hooper, E. G.
*Hosmer, Geo. L.
Houston, Hale
Howitt, Nathan
Hoyt, L. B.
Huacuja, F.
Humphrey, H. K.

Jablow, Charles
Jewett, Arthur C.
Johnson, Lewis J.
Jones, J. O.
Jones, W. B.

Kantner, R. C.
Kennelly, Arthur E.
*Ketchum, Milo S.
Kile, Robert F.

Lange, Paulus
*Lawrence, Russell E.
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Lyon, Daniel R.

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MacKavanaugh, T. J.
MacNutt, Barry
Madigan, John A.
Matheson, E. G.

* Deceased.

McIlhenny, Isbell F.
McLaughlin, Donald H.
McNamara, F. T.
Merrill, Joseph F.
Michel, Rudolph
Miller, Benjamin L.
*Morss, Everett
*Muncy, Victor E.

Neff, Frank H.
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O'Rourke, Edward V.
Owens, H. D.

Pangborn, Redmond J.
*Peffer, H. C.
Perryman, C. C.

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*Rice, H. A.
Riggs, H. E.
Roesch, Daniel
*Rood, Jas. T.
Ruggles, Sydney L.
*Ryan, Harris J.

Scheve, Carl J.
Sheldon, Ernest W.
Slaymaker, R. R.
Staley, Allem C.
Stephenson, S. A., Jr.
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Taylor, Floyd D.
Thomas, R. P.
Trofimov, Leo A.

Van Dyke, James R.
Vicker, John J.
*von Ende, Carl L.

Wadsworth, F. L. O.
Warner, Robert K.
Wegner, W. W.
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